Variation in Biological Characters Among Sockeye Salmon Populations of the Stikine River with Potential Application for Stock Identification in Mixed-Stock Fisheries

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VARIATION IN BIOLOGICAL CHARACTERS AMONG SOCKEYE SALMON POPULATIONS OF THE STIKINE RIVER WITH POTENTIAL APPLICATION FOR STOCK IDENTIFICATION IN MIXED-STOCK FISHERIES

by

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ABSTRACT

Wood, C. C., B. E. Riddell, D. T. Rutherford, and K. Rutherford. 1987. Variation in biological characters among sockeye salmon populations of the Stikine River with potential application for stock identification in mixed-stock fisheries. Can. Tech. Rep. Fish. Aquat. Sci. No. 1535: 61 p.

Sockeye salmon (Oncorhynchus nerka) were collected from principal spawning sites and fisheries within the Stikine River watershed to evaluate the potential for estimating stock composition using biological characters. Samples from spawning sites were examined for age and length composition, scale pattern characteristics, prevalence of the brain parasite Myxobolus neurobius, and electrophoretic variation at up to 24 loci. Sockeye stocks identified on the basis of spawning and rearing habitat (Tahltan Lake, glacial lakes and river stocks) showed significant electrophoretic variation. Electrophoretic variation was not significant among samples from different spawning sites within the river stock group despite relatively large distances separating some sites. Electrophoretic, parasitic, freshwater age and scale pattern characters can all be used to differentiate the Tahltan Lake stock from other non-Tahltan stocks. These data indicate that, on average, about 40% of the sockeye run crossing the Alaska-British Columbia border originates in Tahltan Lake. Electrophoretic and egg diameter data also suggest that both Tahltan and non-Tahltan sockeye are harvested in the fishery at Telegraph Creek on the upper Stikine River; however, the non-Tahltan sockeye probably contribute <20% of the catch. Estimation of stock composition in test fishery catches using biological characters appears to be a valuable tool for enumerating sockeye runs in the Stikine River.

RESUME

Wood, C. C., B. E. Riddell, D. T. Rutherford, and K. Rutherford. 1987. Variation in biological characters among sockeye salmon populations of the Stikine River with potential application for stock identification in mixed-stock fisheries. Can. Tech. Rep. Fish. Aquat. Sci. No. 1535: 61 p.

Des saumons rouges (Oncorhynchus nerka) ont été capturés dans les principaux sites de frai et lieux de pêche du bassin versant de la rivière Stikine afin d'évaluer les possibilités d'estimer la composition des stocks à partir de caractères biologiques. Les poissons capturés dans les aires de frai ont fait l'objet d'un examen portant sur la détermination de l'âge et de la longueur, des caractéristiques des écailles, de la prévalence du parasite du cerveau Myxobolus neurobius et de la variabilité électrophorétique en un nombre de locus pouvant atteindre 24. Les stocks de saumon rouge identifiés à partir des aires de frai et de croissance (stocks du lac Tahltan, de lacs glaciaires et de cours d'eau) présentaient une variabilité électrophorétique significative. Cette variabilité n'était pas significative entre les échantillons provenant de divers aires de frai au sein du groupe de stocks de la rivière, même si certaines zones de frai étaient relativement très éloignées. Les paramètres relatifs à l'analyse électrophorétique, aux parasites, à l'âge en eau douce et aux écailles permettaient tous de différencier le stock du lac Tahltan des autres stocks. Les données obtenues indiquent que, en moyenne, environ 40 % des géniteurs de saumon rouge traversant la frontière Alaska-Colombie-Britannique proviennent du lac Tahltan. Les données électrophorétiques et celles relatives au diamètre des oeufs portent aussi à croire que les saumons rouges du lac Tahltan et des autres stocks sont récoltés par la pêche effectuée dans le ruisseau Telegraph, dans la partie d'amont de la rivière Stikine, mais les saumons rouges ne provenant pas du lac Tahltan constituent probablement moins de 20% des prises. L'estimation de la composition des stocks à partir de caractères biologiques des prises de pêches d'essai s'avère utile comme moyen de dénombrement des remontées de saumons rouges dans la rivière Stikine.

INTRODUCTION

Sockeye salmon (Oncorhynchus nerka) populations in the Stikine River are difficult to study owing to their remote location and to the turbid, glacial water typical of most of the watershed accessible to salmon. In addition, there are numerous spawning sites scattered throughout the main channel of the Stikine and Iskut rivers and their tributaries. Fry emerging from these spawning sites do not have access to lakes; instead, they rear in the slackwater side channels and along the margins of main channels. Production from these river stocks has been especially difficult to assess. Until recently, over 90% of the sockeye salmon run to the Stikine drainage was thought to originate in Tahltan Lake - the only large, clearwater lake accessible to sockeye and amenable to direct observation (Bergmann 1978). Sockeye escapements through the Tahltan Lake weir have ranged between 10,000 and 67,000 in the last 10 years (1976-1985). However, analyses of scale patterns and egg diameter (Craig 1985) and preliminary observations on the prevalence of the protozoan brain parasite Myxobolus neurobius (Dr. L. Margolis, Pacific Biological Station, Nanaimo, B.C. V9R 5K6 pers. comm.), indicated that Tahltan Lake probably contributed less than half of the total sockeye run to the Stikine. Accordingly, an extensive survey of other potential spawning sites was conducted in 1984 by the Northwest Enhancement Society (NWES), sponsored jointly by the Department of the Environment and the Department of Fisheries and Oceans (DFO), to determine the origin of this substantial non-Tahltan sockeye production.

In this report, we document variations in biological characteristics among sockeye salmon collected from the six largest spawning areas in the Stikine watershed identified during the 1984 survey (NWES 1985). These include Tahltan Lake, two glacial lakes (Chutine Lake and Christina Lake) and three river stocks spawning in the Iskut, Chutine and Scud rivers (Fig. 1). The observed variation in scale patterns, freshwater age, parasite prevalence and allele frequencies is sufficient to differentiate major stock-groupings in mixed-stock catches of the commercial fishery in the lower Stikine River.

METHODS

Collection of samples from spawning sites

The Tahltan Lake sockeye salmon population has been sampled annually for length, sex and scale data by the Alaska Department of Fish and Game (ADFG) since 1959, and more recently by DFO, at a weir situated near the lake outlet. Additional samples were also collected by DFO for parasitic and electrophoretic analysis in 1982, 1983, and 1985 (Table 1); random samples were collected in 1982 and 1983 but only females were sampled in 1985 to obtain more data on fecundity and egg diameter.

During the 1984 survey by NWES, random samples of 50-100 spawning sockeye salmon were collected from Chutine Lake, the Chutine River (35 km below the lake), the Scud River, Christina Lake and the Iskut River near its confluence with the Verrett River. Because it was difficult to estimate abundance in the turbid water, samples were taken wherever fish were obviously spawning and concentrated enough to facilitate collection without causing a significant reduction in the observed spawning population. A 12-cm gillnet was used to encircle and "seine" the spawning sockeye. Further samples were obtained in 1985 by NWES from the Scud River, Chutine Lake, Chutine River, the Iskut River near its confluence with the Craig River, and three spawning sites in the main channels of the Iskut and Stikine rivers. These were collected randomly except in the Scud River where only males were collected to avoid depleting the reproductive capacity of the small (observed) spawning group. A single random sample was also collected by NWES in 1983 from the Iskut River near the Verrett River. Sample sizes are summarized in Table 1.

Collection of mixed-stock fishery samples

Adult sockeye salmon were collected from test fisheries in the lower Stikine River about 16 km below the Alaska - B.C. boundary in 1984, and about 3 km above the boundary in 1985 (Fig. 1). In 1984, ADFG operated a sonar counter together with 12- and 13-cm mesh gillnets at both of two sites located on opposite sides of the river. Site A on the south bank was expected to provide a more representative sample of the overall salmon run (Mr. B. Lynch, ADFG, Petersburg, Alaska, pers. comm.). Length, sex, and egg-diameter data, scales, otoliths and brains were collected from up to 200 sockeye per week between June 15 and August 15, 1984.

In 1985, sockeye were collected using 12- and 13.3-cm mesh gillnets fished on different days at a single location for a 24-h period each week. Tissues for electrophoretic analysis (heart, liver, eyeball and skeletal muscle) were collected in addition to the type of data collected in 1984. All fish from the 12-cm mesh net were sampled to obtain a representative sample of the run based on a constant fishing effort. Due to excessive catches during the first 3 wk, the length of the net was reduced from 68 m to 33 m for the remaining 9 wk. A random subsample of 50% was taken to represent the first 3 wk, resulting in a total (representative) sample of 661 fish from the 12-cm net. Up to 100 fish were sampled each week from the 13.3 cm mesh net; a representative sample of the entire run was obtained by subsampling each weeks's catch in proportion to the catch-per-unit-effort in the in-river commercial fishery where a similar mesh size was used.

Two additional samples of 77 and 100 sockeye were obtained with 13.3-cm mesh gillnets during the commercial fishery in the lower Iskut River (site 7 in Fig. 1) on August 4 and August 10-14, 1985, respectively. These fish had not spawned and were assumed to be migrating to spawning grounds in the upper Iskut River. A random sample of 302 sockeye was also collected from the Telegraph Creek subsistence fishery (site 11), July 4 - Aug. 14, 1985.

Sampling Procedures

Whole fish were collected from Tahltan Lake in 1982 and 1983 and from the Iskut River in 1983 and 1984. All other specimens were sampled in the field for length, sex, scales (2 from the preferred area), otoliths, brain (to examine for parasite) and heart, liver, eyeball and muscle tissues for electrophoretic analysis. Round weight, ovary weight, fecundity and egg size data were also recorded for some female sockeye collected in 1985. All fish were alive when captured and tissues were frozen within 6 h of death to preserve enzyme activity. Forceps and knives were wiped and rinsed carefully after sampling each fish to avoid contaminating subsequent specimens with spores of the brain parasite. Otoliths were stored dry in trays; scales were mounted on gum cards.

Scale and otolith analysis

Age was determined from the surface of otoliths as described by Bilton and Jenkinson (1968). Otolith ages were used to interpret scale growth zones since it was rarely possible to determine total age from scales alone owing to resorption of the scale margins in spawning fish. The number of circuli (NC) and the incremental distances (ID) between circuli within growth zones along the anterior-posterior axis (Fig. 2) were measured from projected images at 100 X magnification using a computerized digitizing tablet. Growth zones were delineated by annual checks with the exception of spring ("plus") growth prior to seaward migration; this was recorded separately from marine growth that occurred during the remainder of the year. Incremental distances were measured between inside edges of circuli.

Parasite examination

Brains were examined for the presence of the parasite Myxobolus neurobius following the method recommended by Dr. L. Margolis (Pacific Biological Station, Nanaimo, B.C., V9R 5K6) which involves digestion of the brain in a pepsin-hydrochloric acid solution and microscopic examination of the sediment following centrifugation. Parasite prevalence refers to the proportion of brain samples carrying the parasite. The intensity of infection within individual fish was not evaluated.

Fifty whole sockeye specimens collected in the Iskut River in 1984 were examined for the presence of six additional parasites: Myxidium salvelini (occurring in the kidney), Diphyllobothrium plerocercoids (stomach and mesenteries), Dilepidid cycticercoids (liver), Diplostomum metacercaria (eyes), Tetracotyle metacercaria (kidney, viscera, eye muscles) and Philonema oncorhynchi (swim bladder).

Electrophoretic analysis

Tissue samples were stored at approximately -40°C and later analyzed by horizontal starch gel electrophoresis as described by Utter et al. (1983). Electrophoretic variation was assayed at 24 loci (Table 2) which exhibit

simple Mendelian segregation. Duplicate loci (e.g., MDH-1, 2) could not be scored individually and have been considered as a single locus. Following Allendorf and Utter (1979), alleles at polymorphic loci were designated according to their relative mobility starting with the allele exhibiting the least anodal migration; the most common allele was designated type 100.

Allele frequencies were computed by summing alleles across all (n) genotypes and dividing by the total number of alleles (2n). Genotype frequencies at each locus were examined for departure from Hardy-Weinberg equilibrium by chi-square. The equality of genotype frequencies among spawning populations was examined by likelihood-ratio (e.g., the G-test, Sokal and Rohlf 1969). Average heterozygosities were calculated on the basis of Hardy-Weinberg expectations averaged over all loci. Genetic structuring within the Stikine River watershed was analyzed by comparing gene diversity within and between spawning populations (Nei 1972). A dendrogram of genetic similarity was constructed using unbiased genetic identities (Nei 1978) and the unweighted pair group method (Sneath and Sokal 1973).

RESULTS

Age Composition

Freshwater age composition of spawning sockeye was highly variable among spawning sites and was generally consistent during both 1984 and 1985 (Fig. 3, Table 3). No age 0. fish (i.e., lacking a freshwater check in scales and otoliths) were found in any of the spawning samples from Tahltan, Chutine and Christina lakes. Spawners from Tahltan Lake were predominately age 1. (92 and 97% in 1984 and 1985, respectively). Age 2. spawners were most abundant in the glacial lake populations (43 and 57% in Chutine and Christina lakes respectively, in 1984).

In contrast, age 0. spawners were found in all samples from river sites (sites 4 - 10). The majority of spawners in river sites were age 1.3 (range 64 - 94%) in both 1984 and 1985. The proportion of age 0. sockeye spawning at river sites was higher in 1985 (20%) than in 1984 (6%). However, this may only reflect inadequate sampling since the overall contribution to representative samples from the test fisheries in the lower Stikine River was 4.6 and 4.7% in 1984 and 1985, respectively. Accordingly, we pooled data across years and sites to compute rough estimates of the relative occurrence of age 0. (15%) and age 1. sockeye (85%) in river stocks.

Length distributions and sex ratio

Length distributions for spawning locations are summarized by sex for principal age classes in Figure 4. There were no obvious differences in size at a given age between river and lake-rearing populations in either 1984 or 1985.

Length distributions for the lower river test fishery samples are illustrated in Figure 5. Mesh size of gillnets did not appear to influence the catchability of larger sockeye (> 50 cm post-orbital hypural length). However, small sockeye (< 45 cm) were caught more efficiently with the 12-cm mesh. Thus, samples from the 12-cm mesh net are probably more representative of the overall run of sockeye in the river, although samples in the 13.3-cm mesh would be more representative of the commercial catch.

Sex ratio was fairly stable (averaging 56% female) throughout the 1984 test fishery but exhibited trends in the 1985 test fishery (Table 4). A similar trend was observed in 1983 (Craig 1985). This pattern probably arises because the Tahltan Lake stock passes through the fishery earlier than the river-rearing stocks (Craig 1985; Wood et al. 1987).

Length distributions are also illustrated for samples from commercial catches in the lower Iskut River (Fig. 6) and at Telegraph Creek, (Fig. 7) in 1985. The sex ratio in the Telegraph Creek sample (49% female) is consistent with that recorded at the Tahltan Lake weir (44% female) but differs from that observed in the 1985 test fishery during the early (Tahltan Lake) segment of the run from about June 11 - July 6. This is puzzling since the latter test fishery was designed to give representative samples whereas the Telegraph Creek fishery was sampled opportunistically with no assurance that samples would be representative of the run to the upper Stikine River.

Scale patterns

Scale pattern data are summarized by age group and growth zone for all spawning locations in Table 5 (circulus counts) and Table 6 (incremental distances). Circulus counts for the principal age class common to all stocks, (age 1.3) are also illustrated in Figure 8 to facilitate comparison among stocks and between years. Age 1.3 sockeye from Tahltan Lake generally exhibited greater freshwater growth in the first year (averaging 11.27 circuli), and less plus growth (averaging 1.36 circuli) than sockeye of the same age from other spawning locations for which means ranged between 7.29 - 8.79 and 1.45 - 3.71 circuli, respectively. Circulus counts within different growth zones for individual fish (age 1.2 and 1.3) obtained in the 1984 test fishery in the lower Stikine River were not significantly correlated (Table 7) and therefore, the circulus count in each growth zone can be regarded as an independent character for stock discrimination. These scale characters have already proven useful for distinguishing Tahltan from non-Tahltan sockeye stocks (Mr. G. Oliver, ADFG, P.O. Box 20, Douglas, Alaska 99824, memorandum to D. Cantillon, 5 April 1983; Wood et al. 1987).

Parasite prevalence

Sockeye from river stocks invariably exhibited a greater prevalence of infection by the brain parasite, Myxobolus neurobius (Table 8). The parasite was generally rare in lake-type sockeye with the highest prevalence being only 10% (in Christina Lake, 1984). Prevalence among river stocks ranged from 13-15% in the Iskut River to 66% in the Scud River and 73% in one small sample from the Stikine mainstem. Furthermore, parasite prevalence was

very consistent at all sites sampled repeatedly except Scud River, but those samples were not significantly different either ($p > 0.05$, χ^2). The small sample from site 8 was, however, significantly different from the other mainstem Stikine sites ($p < 0.001$, χ^2). Overall, the average parasite prevalence was 15% for the Iskut River sites, and 37% for all other river sites. The occurrence of other parasites in the sample from the Iskut River is summarized in Table 9.

The prevalence of Myxobolus neurobius in representative samples from the lower river fisheries varied narrowly between 17 and 22% from 1983-1985 (Table 10). In all years, the prevalence increased over the course of the run reaching a peak in mid to late August by which time the majority of the uninfected Tahltan Lake stock had passed through the counting fence into the lake. Only 5 parasitized fish (2%) were detected in samples from the Telegraph Creek fishery in 1985.

There was some evidence to suggest that parasite prevalence was correlated with freshwater age (Table 11). Prevalence among age 0. fish was 39 and 16% in pooled samples from the Stikine River (sites 4, 5, 8, 10) and the Iskut River (sites 6, 7), respectively, compared with 55 and 23% for age 1. fish from the same samples. In the test fishery samples, parasite prevalence among age 0. fish was 31% (n=13) and 27% (n=30) in 1984 and 1985, respectively. Only 2% of fish sampled in the 1985 subsistence fishery at Telegraph Creek (site 11) were parasitized.

Electrophoretic variation

Only 8 of the 24 loci examined by electrophoresis were polymorphic to the extent that common (100) allele frequencies were less than 0.99 (Table 12). Average heterozygosities over the 24 loci ranged from 0.034 to 0.050 among populations sampled. Only 5 of the 74 chi-square tests for deviation of the observed genotypic frequencies from the expected Hardy-Weinberg genotypic frequencies were statistically significant at the 5% critical value. The five most polymorphic loci (LDH-4, PGM-1, PGM-2, AAT-3, IDH-4) all varied significantly between stocks identified on the basis of spawning habitat (Talhtan lake, glacial lakes, and river stocks). Variation at the LDH-4 locus was by far the most significant difference between populations. The 100-type allele for LDH-4 was present at a frequency between 0.378 to 0.431 in Talhtan Lake sockeye but was much more prevalent in non-Talhtan sockeye (0.854 to 0.956 in frequency). Tests of the homogeneity of gene frequencies between spawning ground samples indicated highly significant heterogeneity between the three sub-populations, limited variation between local demes within sub-populations, and homogeneous frequencies between years within demes (Table 13). Variation between sub-populations summed over the 5 most polymorphic loci was greater than 25 times the variation between demes within sub-populations.

The sub-populations identified showed moderate (averaged value over the 5 loci used in Table 13) to high (LDH-4 only) levels of genetic differentiation (Table 14). Sub-division of the three groups of populations into demes did not indicate significant differentiation between demes (i.e.,

heterogeneity of allele frequencies was significantly greater between sub-populations than within). Furthermore, the allele frequencies in Table 12 and the F statistics in Table 14 indicate that the greatest degree of differentiation occurs between the Tahltan populations and all other non-Tahltan populations (Fig. 9). Figure 9 also indicates that river populations are more similar to each other than to other lake-rearing populations.

Stock composition of the Telegraph Creek food fishery

It has usually been assumed that the vast majority of sockeye caught at Telegraph Creek were destined for Tahltan Lake (Mr. S. Johnston, DFO, Whitehorse, Yukon, pers. comm.). However, samples taken from this fishery in 1985 reveal that at least one other stock is contributing to the catch. The strongest evidence for the existence of another stock comes from measurements of egg diameter. Craig (1985) and Wood et al. (1987) demonstrated that female sockeye from Tahltan Lake carry smaller eggs than other Stikine River stocks at least until they pass through the counting fence and into the lake. Distributions of egg diameter are presented in Figure 9 for samples taken at Tahltan Lake and at Telegraph Creek in 1985. It is evident from this figure that just over 10% of the fish from Telegraph Creek lie outside the range in egg diameter observed at Tahltan Lake. Moreover, the Telegraph Creek distribution is obviously skewed towards fish carrying larger eggs whereas the Tahltan Lake distribution is approximately normal.

A comparison of allele frequencies at the LDH-4 and PGM-2 loci for the Tahltan Lake and Telegraph Creek samples (Table 12) also reveals a marginally statistically significant ($p<0.05$) difference. This difference is adequately explained if we assume that 10-20% of the Telegraph Creek sample is comprised by another river stock with an allele frequency at LDH-4 and PGM-2 typical of that observed for river stocks sampled farther downstream (e.g., Chutine River and Scud River).

Since the prevalence of Myxobolus neurobius was only 2% in the Telegraph Creek sample, compared to 1% in the Tahltan Lake sample, it follows that the prevalence in the unidentified stock(s) would be > 5% assuming it contributes no more than 20% to Telegraph Creek catch. If we assume that juveniles from this river stock rear in the same habitat as those from river stocks farther downstream, we might expect a comparable prevalence of Myxobolus (around 40%). This would imply that the unidentified stock contributes <5% to the Telegraph Creek fishery.

Unfortunately, it is not known how well the Telegraph Creek samples represented the overall catch at Telegraph Creek in 1985, and it is not possible to deduce precisely the magnitude of the non-Tahltan component. Nevertheless, the available evidence suggests that a non-Tahltan stock does spawn above Telegraph Creek, and may comprise up to 10-20% of the catches there.

DISCUSSION

Substantial variation exists among the major sockeye salmon stocks in the Stikine River with respect to freshwater age composition, scale patterns, the prevalence of the brain parasite, Myxobolus neurobius, and allele frequencies at the LDH-4 locus. These biological characteristics are potentially very useful for determining the stock structure of the Stikine River sockeye run. Wood et al. (1987) estimated the stock composition of sockeye catches by test fisheries in the lower Stikine River near the international boundary in 1984 and 1985. Using the characteristics described in this report, they were able to differentiate with reasonable precision (± 5-10% with 95% confidence depending on sample sizes), three major stock-groupings--Tahltan Lake, the glacial lakes (Chutine Lake and Christina Lake) and the river stocks (Iskut River, Scud River, and Chutine River). It was not possible to differentiate the individual river stocks accurately since they resemble one another so closely for most attributes measured so far, despite the fact they are widely separated geographically. It seems likely that progeny from sockeye spawning in the Chutine and Scud rivers, and similar tributaries, share the same rearing areas in the mainstem of the Stikine River. This would account for the similarity in scale patterns, freshwater age composition and the prevalence of Myxobolus neurobius. Wood et al. (1987) assume that the Chutine River and Scud River populations are representative of other, smaller spawning stocks scattered along the mainstem of the Stikine River.

In many respects, Tahltan Lake sockeye are unique within the Stikine system, and hence, readily differentiated from non-Tahltan sockeye. This is fortunate since Tahltan Lake spawners are comparatively easy to enumerate at a counting fence situated near the lake's outlet. Once relative estimates of stock composition in the lower river have been obtained for the major stock-groupings (including Tahltan Lake), it is possible to compute corresponding absolute estimates of escapement using the Tahltan Lake weir counts. For example, in 1985, it was estimated that Tahltan Lake sockeye contributed 36% of the sockeye run crossing the international boundary which is usually referred to as the "border escapement" (Wood et al. 1987). Since the escapement to Tahltan Lake including 80% (conservatively) of the catch at Telegraph Creek was about 74,000, it follows that the border escapement was about 206,000 (i.e., 74,000/0.36). It was also estimated that the glacial lake and river stocks contributed 11% and 53%, respectively, to the border escapement (Wood et al. 1987). Escapements to these areas can be calculated by taking these proportions of the border escapement, less the commercial catch in the lower river (206,000 - 17,093 = 189,000). This implies escapements of 21,000 for the glacial lakes and 100,000 for the river stocks.

It would be virtually impossible to enumerate the river stocks directly owing to their sparse but widespread occurrence within the Stikine River system (NWES 1985) and to the turbidity of the water. Thus, stock composition analysis may prove to be a valuable tool for estimating escapements in the Stikine River and in other habitats where direct enumeration is impractical. However, the accuracy of such indirect estimates of escapement will depend upon the reliability of the stock identification procedures and on how well samples from test fisheries represent the actual composition of the salmon run.

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Table 1. Summary of sockeye salmon collections from spawning grounds in the Stikine River watershed, 1982-1985.

Spawning area	Year	Number of spawning sockeye sampled for: Length/ sex	Fecundity	Otoliths	Scales	Brains for parasite	Tissues for electrophoresis
Tahltan Lake[a]	1982	1384		0	1384	30	98
	1983	1883		0	1883	100	102
	1984	2210	0	0	2210	0	0
	1985	2742	45	135	2742	100	100
Christina Lake	1984	76	0	76	76	50	76
Chutine Lake	1984	100	-	100	100	100	100
	1985	131	-	50	131	50	50
Chutine River	1984	62	-	62	62	62	62
	1985	92		50	92	50	50
Scud River	1984	50	-	50	50	50	50
	1985	68	16	68	68	68	68
Iskut River:							
at Verrett River	1983	110	0	0	110	110	112
	1984	151	0	151	151	151	151
	1985	159	83	159	159	159	159
10 km above[b] confluence with Stikine	1985	177	43	177	177	177	177
Mainstem Stikine:	1983	118	0	0	0	118	118
10 km above confluence with Iskut	1985	0	0	77	0	77	0
at Telegraph Creek[b]	1985	302	130	302	302	300	169

[a]Includes length/sex/scale data collected by Department of Fisheries and Oceans staff in Whitehorse, Yukon.

[b]Samples probably contain sockeye migrating to upstream areas and may not be typical of mainstem river spawners.

Table 2. Enzymes and tissues used to investigate genetic variation in sockeye salmon. Buffers used were (AC) an amine citrate buffer described by Clayton and Tretiak (1972), and (RW) a Tris, citric acid, lithium hydroxide, and boric acid buffer described by Ridgway et al. (1970).

Enzyme	Tissue	Locus	Buffer
Aspartate aminotransferase	Heart	AAT-1,2	AC
	Eye	AAT-3	AC
Aconitase	Liver	ACON-3	AC
Adenosine deaminase	Muscle	ADA-2	AC
α-Glycerophosphate dehydrogenase	Muscle	AGP-1	AC
Glyceraldehyde-phosphate dehydrogenase	Eye	GAP-4,5	AC
Isocitrate dehydrogenase	Muscle	IDH-1,2	AC
	Liver	IDH-3,4	AC
	Eye	IDH-3,4	AC
Lactate dehydrogenase	Muscle	LDH-1,2	RW,AC
	Heart	LDH-3	AC
	Liver	LDH-4	RW
	Eye	LDH-5	RW
Malate dehydrogenase	Liver	MDH-1,2	AC
	Muscle	MDH-3,4	AC
Malic enzyme	Muscle	ME-1,3	AC
Phosphoglucoisomerase	Muscle	PGI-1,2,3	RW
Phosphoglucomutase	Heart	PGM-1	AC
	Muscle	PGM-2	RW
Phosphomannoisomerase	Heart	PMI	AC
Tetrazoliumoxidase	Muscle	TO	RW
6-Phosphogluconate dehydrogenase	Muscle	6-PG	AC

Table 3. Age distributions by sample for adult sockeye salmon from the Stikine River system. Age was determined from both scales and otoliths except as noted.

Spawning area	Year	No. aged	Proportion of fish in each age-class (number in parentheses)											
			0.2	0.3	0.4	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.3
Tahltan Lake	1984[a]	85	-	-	-	-	.38(32)	.55(47)	-	-	-	.07(6)	-	-
	1985[b]	126	-	-	-	-	.08(10)	.90(114)	-	-	.02(2)	-	-	-
Christina Lake	1984	72	-	-	-	-	.01(1)	.42(30)	-	-	.04(3)	.51(37)	.01(1)	-
Chutine Lake	1984	80	-	-	-	-	.23(18)	.34(27)	-	.01(1)	.25(20)	.16(13)	-	.01(1)
	1985	45	-	-	-	-	.20(9)	.24(11)	-	-	.31(14)	.24(11)	-	-
Chutine River	1984	61	-	.02(1)	-	-	.13(8)	.82(50)	-	-	-	.03(2)	-	-
	1985	47	-	.04(2)	-	.02(1)	-	.94(44)	-	-	-	-	-	-
Scud River	1984	44	-	.23(10)	-	-	.09(4)	.64(28)	-	-	-	.05(2)	-	-
	1985	66	.02(1)	.17(11)	.02(1)	-	.04(3)	.76(50)	-	-	-	-	-	-
Iskut River:														
at Verrett River	1984	140	-	.02(3)	-	.01(1)	.14(20)	.79(111)	.01(1)	-	.01(2)	.01(2)	-	-
	1985	156	.01(2)	.17(27)	-	-	.08(12)	.69(107)	.01(1)	-	.01(1)	.04(6)	-	-
10 km above Confluence with Stikine	1985	170	.01(2)	.15(26)	-	-	.15(25)	.65(111)	.01(1)	-	.01(1)	.02(4)	-	-
Mainstem Stikine:														
10 km above confluence with Iskut at Telegraph Creek	1985	75	.03(2)	.41(31)	-	-	.04(3)	.49(37)	.01(1)	-	-	.01(1)	-	-
	1985[b]	273	.00(1)	-	-	-	.03(8)	.91(249)	-	-	.03(7)	.03(8)	-	-

[a]Age determined from scales only.

[b]Age determined from otoliths only.

Table 4. Sex composition of sockeye samples from lower Stikine River fisheries in 1984 and 1985.

Date	Proportion Female (number in parentheses)		
	1985 Test Fishery (12-cm mesh)	1985 Test Fishery (13.3-cm mesh)	1984 Test Fishery (12 and 13.3-cm mesh)
June 11-15	0.50(8)	0.70(20)	-
June 16-21	-	0.56(36)	-
June 22-27	0.68(34)	0.67(100)	0.63(16)
June 28-July 6	0.62(175)	0.52(157)	0.60(159)
July 7-13	0.71(45)	0.55(100)	0.60(84)
July 14-20	0.61(94)	0.54(100)	0.56(70)
July 21-26	0.41(76)	0.52(99)	0.48(77)
July 27-Aug 1	0.52(110)	0.48(100)	0.51(75)
Aug 2-10	0.54(76)	0.58(100)	0.61(80)
Aug 11-17	0.57(58)	0.52(100)	0.51(45)
Aug 18-24	0.51(39)	0.52(100)	-
Aug 25-31	0.49(53)	0.32(44)	-

Table 5. Mean number of circuli in scale zones of principal age classes of sockeye salmon. Standard deviations are given in parentheses. Note that NC_1 for age 0.fish refers to the first year of marine growth.

Age class 0.2 Location	Year	n	NC_1 (SD)		
Scud R.	1985	1	35.00(-)		
Age class 0.3					
Location	**Year**	**n**	**NC_1 (SD)**		
Chutine R.	1984	1	34.00 (-)		
Skud R.	1984	8	34.13 (3.04)		
	1985	7	36.57 (2.23)		
Iskut R.	1984	3	35.33 (3.06)		
	1985	36	35.39 (3.16)		
Age class 1.2					
Location	**Year**	**n**	**NC_1 (SD)**	**NC_2 (SD)**	**NC_3 (SD)**
Tahltan L.	1984	27	12.30 (1.61)	1.70 (0.87)	27.22 (2.49)
Chutine L.	1984	12	7.25 (1.55)	2.08 (1.24)	30.50 (3.66)
	1985	8	8.63 (2.07)	2.63 (0.92)	29.25 (2.31)
Chutine R.	1984	7	7.43 (1.72)	1.00 (0.82)	27.43 (4.04)
Scud R.	1984	4	8.50 (1.73)	1.50 (0.58)	28.85 (3.20)
	1985	2	8.00 (1.41)	1.50 (0.71)	30.00 (2.83)
Iskut R.	1984	12	8.17 (1.59)	1.83 (1.03)	27.58 (2.15)
	1985	30	8.23 (1.48)	2.30 (1.26)	29.30 (3.17)
Age class 1.3					
Location	**Year**	**n**	**NC_1 (SD)**	**NC_2 (SD)**	**NC_3 (SD)**
Tahltan L.	1984	44	11.27 (1.23)	1.36 (0.53)	27.50 (2.72)
	1985	26	11.42 (1.72)	1.31 (0.47)	25.31 (2.02)
Christina L.	1984	20	8.05 (1.32)	1.45 (0.89)	28.80 (2.63)
Chutine L.	1984	15	7.80 (1.78)	1.53 (0.92)	30.67 (3.60)
	1985	7	7.29 (2.36)	3.71 (2.14)	28.57 (3.31)
Chutine R.	1984	36	8.36 (2.34)	2.03 (1.63)	28.58 (3.71)
	1985	16	8.00 (2.03)	2.31 (1.01)	29.06 (2.46)
Scud R.	1984	18	8.17 (1.65)	2.39 (0.98)	30.06 (2.98)
	1985	39	8.77 (2.01)	1.85 (0.90)	28.64 (2.43)
Iskut R.	1984	70	8.73 (1.70)	2.36 (1.18)	28.58 (3.71)
	1985	152	8.79 (1.72)	1.94 (0.92)	29.48 (2.67)

Table 5 (cont'd)

Age class 2.2 Location	Year	n	NC_1 (SD)	NC_2 (SD)	NC_3 (SD)	NC_4 (SD)
Christina L.	1984	2	5.50 (0.71)	6.00 (0)	1.00 (0)	23.00 (1.41)
Chutine L.	1984	11	5.73 (1.49)	10.55 (1.51)	1.27 (0.47)	27.46 (3.14)
	1985	10	5.60 (1.51)	10.80 (1.69)	1.90 (0.74)	26.20 (2.57)
Iskut R.	1984	1	7.00 (-)	8.00 (-)	2.00 (-)	27.00 (-)
	1985	1	9.00 (-)	8.00 (-)	4.00 (-)	20.00 (-)
Age class 2.3 Location	**Year**	**n**	**NC_1 (SD)**	**NC_2 (SD)**	**NC_3 (SD)**	**NC_4 (SD)**
Tahltan L.	1984	6	7.33 (1.37)	9.33 (1.51)	1.00 (0)	24.67 (5.09)
Christina L.	1984	27	6.30 (0.95)	6.15 (0.86)	1.33 (0.62)	23.00 (1.41)
Chutine L.	1984	7	5.57 (0.53)	9.71 (0.95)	1.86 (1.07)	24.29 (5.12)
	1985	8	5.75 (1.98)	11.00 (1.69)	1.75 (1.17)	25.75 (2.87)
Chutine R.	1984	1	5.00 (-)	7.00 (-)	2.00 (-)	29.00 (-)
Scud R.	1984	1	5.00 (-)	9.00 (-)	1.00 (-)	27.00 (-)
Iskut R.	1985	8	6.00 (1.41)	6.38 (2.07)	2.13 (0.83)	29.00 (3.42)

Table 6. Mean incremental distances (mm x 100) in scale zones of principal age classes of sockeye salmon. Standard deviations are given in parentheses. Note that ID, for age 0. fish refers to the first year of marine growth.

Age class 0.2 Location	Year	n	ID_1 (SD)
Scud R.	1985	1	125.12 (-)

Age class 0.3 Location	Year	n	ID_1 (SD)
Chutine R.	1984	1	116.86 (-)
Scud R.	1984	8	126.44 (13.88)
	1985	7	144.87 (9.22)
Iskut R.	1984	3	136.91 (17.30)
	1985	36	141.13 (12.24)

Age class 1.2 Location	Year	n	ID_1 (SD)	ID_2 (SD)	ID_3 (SD)
Tahltan L.	1984	27	33.60 (4.00)	3.05 (1.47)	100.68 (10.62)
Chutine L.	1984	12	19.86 (4.09)	4.11 (2.78)	110.88 (10.88)
	1985	8	24.23 (4.90)	4.73 (2.46)	106.00 (12.65)
Chutine R.	1984	7	23.43 (7.76)	1.69 (1.61)	103.76 (15.90)
Scud R.	1984	4	28.57 (7.55)	3.22 (1.39)	110.09 (8.31)
	1985	2	25.57 (4.19)	3.14 (1.81)	121.15 (11.18)
Iskut R.	1984	12	24.57 (4.61)	3.51 (1.65)	106.77 (9.18)
	1985	30	24.50 (5.53)	4.75 (4.06)	109.27 (10.75)

Age class 1.3 Location	Year	n	ID_1 (SD)	ID_2 (SD)	ID_3 (SD)
Tahltan L.	1984	44	31.33 (3.27)	2.28 (1.02)	97.39 (9.70)
	1985	26	31.52 (4.08)	2.69 (1.27)	97.46 (6.58)
Christina L.	1984	20	23.96 (4.85)	2.62 (2.15)	107.04 (8.05)
Chutine L.	1984	15	23.74 (4.69)	2.90 (2.07)	111.24 (11.97)
	1985	7	21.55 (5.87)	8.19 (5.09)	108.02 (10.00)
Chutine R.	1984	36	25.28 (7.23)	4.27 (3.79)	107.16 (13.00)
	1985	16	23.27 (6.02)	5.44 (2.65)	111.03 (9.43)
Scud R.	1984	18	25.58 (4.64)	5.06 (2.52)	109.63 (10.03)
	1985	39	26.81 (6.50)	4.15 (2.21)	109.95 (8.79)
Iskut R.	1984	70	24.05 (4.24)	5.01 (2.95)	113.45 (14.08)
	1985	152	25.95 (5.53)	4.24 (2.26)	113.59 (9.54)

Table 6 (cont'd)

Age class 2.2 Location	Year	n	ID_1 (SD)	ID_2 (SD)	ID_3 (SD)	ID_4 (SD)
Christina L.	1984	2	15.68 (1.64)	12.76 (0.13)	1.73 (0.39)	108.05 (7.62)
Chutine L.	1984	11	16.58 (2.80)	22.87 (3.71)	2.74 (0.93)	103.00 (7.36)
	1985	10	17.02 (3.37)	24.57 (4.74)	4.21 (1.84)	101.67 (12.73)
Iskut R.	1984	1	22.47 (-)	18.86 (-)	4.10 (-)	104.16 (-)
	1985	1	26.49 (-)	17.23 (-)	8.16 (-)	70.30 (-)
Age class 2.3 Location	**Year**	**n**	**ID_1 (SD)**	**ID_2 (SD)**	**ID_3 (SD)**	**ID_4 (SD)**
Tahltan L.	1984	6	21.93 (2.80)	20.81 (2.48)	2.00 (0.58)	90.98 (14.22)
Christina L.	1984	27	17.94 (2.17)	13.03 (1.92)	2.20 (1.19)	104.76 (7.76)
Chutine L.	1984	7	16.01 (2.55)	20.52 (3.17)	4.10 (3.02)	85.63 (15.02)
	1985	8	18.44 (5.74)	25.78 (4.86)	4.01 (2.35)	99.16 (5.34)
Chutine R.	1984	1	15.68 (-)	15.09 (-)	5.02 (-)	110.69 (-)
Scud R.	1984	1	14.56 (-)	15.66 (-)	2.83 (-)	101.10 (-)
Iskut R.	1985	8	19.59 (3.11)	14.12 (4.84)	4.58 (1.81)	117.43 (12.07)

Table 7. Correlation of scale measurements within individual fish by age class for sockeye samples from the 1984 test fishery in the lower Stikine River.

Age 1.2	n=108		
	NC_1	NC_2	NC_3
NC_1	1.000	-	-
NC_2	0.186	1.000	-
NC_3	-0.274	-0.078	1.000
Age 1.3	**n=125**		
	NC_1	NC_2	NC_3
NC_1	1.000	-	-
NC_2	0.030	1.000	-
NC_3	-0.302	-0.159	1.000

Table 8. Prevalence of the brain parasite, Myxobolus neurobius, in sockeye salmon by sample location, 1982-1985.

Sample Location	Year	Number examined	Number infected	Proportion infected
Tahltan Lake	1982	30	0	0
	1983	100	0	0
	1985	99	1	0.01
Christina Lake	1984	50	5	0.10
	1985[a]	46	0	0
Chutine Lake	1984	100	9	0.09
	1985	50	2	0.04
Chutine River	1984	62	29	0.47
	1985	50	22	0.44
Scud River	1984	50	33	0.66
	1985	67	33	0.49
Stikine Mainstem:				
site 8	1985	22	16	0.73
site 9	1983	118	40	0.34
site 10	1985	53	15	0.28
all sites	--	193	71	0.37
Iskut River:				
at Verrett R	1983	110	17	0.15
	1984	151	23	0.15
	1985[b]	159	21	0.13
site 7	1985	177	26	0.15
all sites	--	597	87	0.15

[a]not adult specimens; parasite prevalence tends to be underestimated by 5-10% in smolt samples.

[b]Aug. 10 and Sept. 8 samples combined.

Table 9. Prevalence of other parasites in samples of sockeye spawning in the Iskut River (site 6) in 1984.

Parasite	Number examined	Number infected	Proportion infected
Myxidium salvelini	51	0	0.00
Diphyllobothrium plerocercoids	51	4	0.08
Dilepidid cycticercoids	51	0	0.00
Diplostomum metacercaria	51	0	0.00
Tetracotyle metacercaria	51	8	0.16
Philonema oncorhynchi	51	0	0.00

Table 10. Prevalence of the brain parasite, Myxobolus neurobius, in sockeye samples from mixed-stock fisheries.

Location	Year	Date	Number examined	Number infected	Proportion infected	Weighting factor
Lower Stikine (commercial fishery)	1983	July 4-14	175	12	0.07	0.99
		July 18-28	44	8	0.18	1.00
		Aug. 1-11	51	20	0.39	0.82
		Aug. 17-25	48	22	0.46	0.19
		Weighted average			0.22[a]	
Lower Stikine (test fishery)	1984	June 8-23	19	4	0.21	0.22
		June 24-July 7	195	18	0.09	0.56
		July 8-23	243	56	0.23	1.00
		July 24 - Aug. 7	183	61	0.33	0.49
		Aug. 8-23	53	16	0.30	0.15
		Weighted average			0.22[b]	
Lower Stikine (test fishery with 12-cm mesh)	1985	June 10-23	42	4	0.10	0.50
		June 24 - July 8	245	8	0.03	0.75
		July 9-22	169	21	0.12	1.00
		July 23 - Aug. 3	176	44	0.25	1.00
		Aug. 4-19	96	23	0.24	1.00
		Aug. 20 - Sept. 10	62	25	0.40	1.00
		Weighted average			0.21[a]	
Lower Stikine (test fishery with 13.3-cm mesh)	1985	June 15-28	156	15	0.10	0.22
		June 29 - July 12	257	11	0.04	0.63
		July 13-26	200	32	0.16	1.00
		July 27 - Aug. 9	200	52	0.26	0.45
		Aug. 10-23	200	81	0.41	0.20
		Aug. 24 - Sept 23	79	27	0.34	0.06
		Weighted average			0.17[a]	
Telegraph Creek (commercial fishery)	1985	July 4-17	16	0	0.00	0.04
		July 18-31	185	3	0.02	1.00
		Aug. 1-14	86	2	0.02	0.93
		Weighted average			.02[a]	

[a]Weighted average based on catch/24 hours/fishing license.

[b]Weighted average based on sonar fish counts.

Table 11. Prevalence of the brain parasite, Myxobolus neurobius, in spawning sockeye by stock and freshwater-age class.

Location	Year	Freshwater age	Number examined	Proportion parasitized
Chutine R.	1984	0.	1	0.00
(site 4)	1985	0.	2	0.00
	1984	1.	58	0.48
	1985	1.	46	0.48
Scud R.	1984	0.	10	0.40
(site 5)	1985	0.	13	0.35
	1984	1.	33	0.73
	1985	1.	53	0.53
Iskut R.	1984	0.	3	0.33
(site 6)	1985	0.	29	0.10
	1984	1.	135	0.15
	1985	1.	123	0.12
Iskut R.	1985	0.	26	0.19
(site 7)	1985	1.	147	0.42
Stikine Mainstem	1985	0.	5	0.60
(site 8)	1985	1.	16	0.81
Stikine Mainstem	1985	0.	28	0.18
(site 10)	1985	1.	23	0.43
Pooled	1984-1985	0.	117	0.22
(all sites)		1.	634	0.35

Table 12. Summary of allele frequencies by locus and sample.

	Population[a]															
LOCUS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
LDH-4																
(n)	98	102	100	100	50	62	50	50	68	76	45	332	151	112	114	169
100	0.378	0.431	0.430	0.945	0.950	0.855	0.880	0.890	0.926	0.947	0.956	0.886	0.854	0.915	0.912	0.503
115	0.617	0.569	0.570	0.050	0.050	0.145	0.120	0.110	0.074	0.053	0.044	0.113	0.136	0.085	0.088	0.497
85	0.005	0.000	0.000	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.010	0.000	0.000	0.000
PGM-2																
(n)	98	102	97	99	49	61	48	48	65	75	0	331	148	111	115	163
100	0.959	0.936	0.969	0.854	0.837	0.820	0.792	0.833	0.831	0.727		0.796	0.824	0.784	0.826	0.936
120	0.036	0.049	0.031	0.106	0.143	0.164	0.198	0.146	0.162	0.247		0.201	0.176	0.207	0.170	0.061
142	0.005	0.015	0.000	0.040	0.020	0.016	0.010	0.021	0.008	0.027		0.003	0.000	0.009	0.004	0.003
AAT-3																
(n)	31	66	97	88	49	55	50	44	66	72	42	156	95	31	24	0
100	0.887	0.848	0.871	0.977	0.918	0.982	0.980	0.966	0.992	0.986	1.000	0.994	1.000	0.984	1.000	
85	0.113	0.152	0.129	0.023	0.082	0.018	0.020	0.034	0.008	0.014	0.000	0.006	0.000	0.016	0.000	
PGM-1																
(n)	96	89	98	99	49	61	48	48	65	75	0	331	149	60	113	163
100	0.188	0.135	0.189	0.328	0.357	0.246	0.167	0.188	0.162	0.187		0.207	0.161	0.183	0.195	0.156
NULL	0.813	0.865	0.811	0.672	0.643	0.754	0.833	0.813	0.838	0.813		0.793	0.839	0.817	0.805	0.844
IDH-4																
(n)	98	101	100	98	49	60	50	50	67	74	44	157	99	110	113	0
100	1.000	1.000	1.000	1.000	1.000	0.967	1.000	0.990	0.985	0.993	1.000	1.000	1.000	1.000	1.000	
162	0.000	0.000	0.000	0.000	0.000	0.033	0.000	0.010	0.015	0.007	0.000	0.000	0.000	0.000	0.000	
AAT-1,2[b]																
(n)	36	101	99	100	49	62	48	50	68	76	0	159	100	61	0	0
100	1.000	1.000	1.000	1.000	1.000	0.992	1.000	1.000	1.000	0.980		1.000	1.000	1.000		
MDH-3,4[b]																
(n)	98	102	99	100	50	62	49	49	68	76	46	159	100	111	117	0
100	1.000	1.000	1.000	1.000	1.000	1.000	0.980	1.000	1.000	1.000	1.000	0.991	1.000	0.991	0.996	
120	0.000	0.000	0.000	0.000	0.000	0.000	0.020	0.000	0.000	0.000	0.000	0.009	0.000	0.009	0.004	

Table 12 (cont'd)

	Population															
Locus	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
LDH-3																
(n)	80	100	99	100	49	62	50	50	68	76	46	159	100	110	114	0
100	0.994	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.989	1.000	1.000	1.000	1.000	
150	0.006	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.011	0.000	0.000	0.000	0.000	
ACON-3																
(n)	32	101	96	92	48	56	49	49	66	72	46	156	98	92	64	0
100	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	
ADA-2																
(n)	0	0	99	100	49	60	50	49	63	75	46	156	100	0	0	0
100			1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000			
AGP-1																
(n)	97	102	99	99	50	61	50	49	65	76	46	154	96	98	110	0
100	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.992	1.000	1.000	0.987	0.990	1.000	0.995	
95	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.008	0.000	0.000	0.013	0.010	0.000	0.005	
GAP-4,5[b]																
(n)	0	0	100	95	49	61	48	48	67	65	46	158	96	0	0	0
100			1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000			
IDH-1,2[b]																
(n)	0	0	98	100	50	62	50	49	65	76	46	155	99	0	0	0
100			1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.993	1.000	1.000	1.000			
60			0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.007	0.000	0.000	0.000			
IDH-3																
(n)	98	101	97	95	50	61	50	50	68	71	43	332	150	110	113	169
100	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
85	0.000	0.000	0.000	0.000	0.000	0.008	0.000	0.000	0.000	0.020		0.000	0.000	0.000		

Table 12 (cont'd)

Locus	Population 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
LDH-1,2[b]																
(n)	0	101	99	100	49	62	50	48	68	74	46	151	100	0	0	0
100		1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000			
LDH-5																
(n)	96	102	100	92	49	61	49	45	66	75	46	158	98	83	113	0
100	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	
MDH-1,2[b]																
(n)	96	102	98	99	48	62	50	39	68	76	45	157	100	112	114	0
100	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	
ME-1																
(n)	98	80	99	100	50	62	50	49	67	76	46	158	100	105	116	0
100	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.997	1.000	1.000	1.000	
125	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.000	0.000	0.000	
PGI-1																
(n)	98	95	100	99	49	62	50	49	68	73	46	152	98	96	39	0
100	1.000	1.000	1.000	1.000	1.000	0.992	1.000	0.990	1.000	1.000	1.000	1.000	0.995	1.000	1.000	
65	0.000	0.000	0.000	0.000	0.000	0.008	0.000	0.010	0.000	0.000	0.000	0.000	0.005	0.000	0.000	
PGI-2																
(n)	98	95	100	99	49	62	50	49	68	73	46	152	98	96	39	0
100	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	
PGI-3																
(n)	98	95	100	99	49	62	50	49	68	73	46	152	98	96	39	0
100	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	
PMI																
(n)	98	92	99	100	49	62	50	50	64	76	46	159	100	108	60	0
100	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	

Table 12 (cont'd)

	Population															
Locus	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
TO																
(n)	72	102	100	90	50	62	50	49	68	74	45	159	99	101	116	0
100	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	
6PG																
(n)	96	102	99	99	49	62	50	49	68	76	46	159	100	109	115	0
100	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	

[a]Key To Populations

1 = Tahltan L. 1982
2 = Tahltan L. 1983
3 = Tahltan L. 1985
4 = Chutine L. 1984
5 = Chutine L. 1985
6 = Chutine R. 1984
7 = Chutine R. 1985
8 = Scud R. 1984
9 = Scud R. 1985
10 = Christina L. 1984
11 = Christina L. 1985
12 = Iskut R. 1985
13 = Iskut R. 1984
14 = Iskut R. 1983
15 = Stikine R. Mainstem 1983
16 = Telegraph Creek 1985

[b]Duplicate loci considered as single locus.

Table 13. Tests of the homogeneity of allele frequencies between samples for the five most polymorphic loci sampled. Likelihood ratio statistic (G-test, Sokal and Rohlf 1969) are calculated between sub-populations sampled (Talhtan Lake, river stocks, and glacial lakes), between demes sampled within sub-populations, and between annual replicates within demes.

	Loci											
	LDH-4		PGM-1		PGM-2		AAT-3		IDH-4		Summed G = stat.	
Contrast	d.f.	G	d.f.	G	d.f.	G	d.f.	G	d.f.	G	d.f.	G
Between Sub-populations	4	639.3*	2	22.3*	4	112.7*	2	91.6*	2	5.3*	14	871.2
Between demes within "river stocks" sub-population	6	7.2	3	1.1	6	7.1	3	5.0	3	16.2*	21	36.6
Between years:												
Iskut R.	4	8.5	2	2.2	4	3.6	2	3.0	2	0.0	14	17.3
Scud R.	2	0.9	1	0.1	2	0.8	1	0.8	1	0.1	7	2.7
Chutine R.	2	0.3	1	1.6	2	0.5	1	0.2	1	2.1	7	4.7
Between demes: within "glacial lakes" sub-population	2	1.2	1	10.9*	2	11.6*	1	4.8*	1	0.01	7	28.5
Between years:												
Chutine L.	2	0.8	1	0.1	2	1.6	1	3.7	1	0.0	7	6.2
Christina L.	2	0.1	-	-	-	-	1	0.1	1	0.1	4	0.3
Between years in "Talhtan Lake" sub-population	4	3.7	2	2.3	4	5.7	2	0.6	2	0.0	14	12.3

*indicates significance of the G-statistic (d.f. = (a-1)(b-1)) at $p>0.05$).

Table 14. Mean heterozygosity across all demes (H_T) and percent reduction in H_T associated with all levels of population structure (eg., Hartl 1980: p. 405)

Parameter	Locus					Reduction
	LDH-4	PGM-1	PGM-2	AAT-3	IDH-4	
H_T	0.3074	0.3287	0.2661	0.0785	0.0086	-
F_{DT}	26.38	2.22	3.30	6.10	1.85	7.97%
F_{ST}	26.25	2.22	3.30	6.05	1.87	7.94%
F_{DS}	0.18	0.01	0.01	0.05	0.02	0.05%
No. of demes	15	14	14	15	15	

F_{DT} = reduction associated with sub-populations and demes within sub-populations;

F_{ST} = reduction associated with sub-populations (Talhtan, river stocks, and glacial lakes);

F_{DS} = reduction associated with the division of sub-populations into demes.

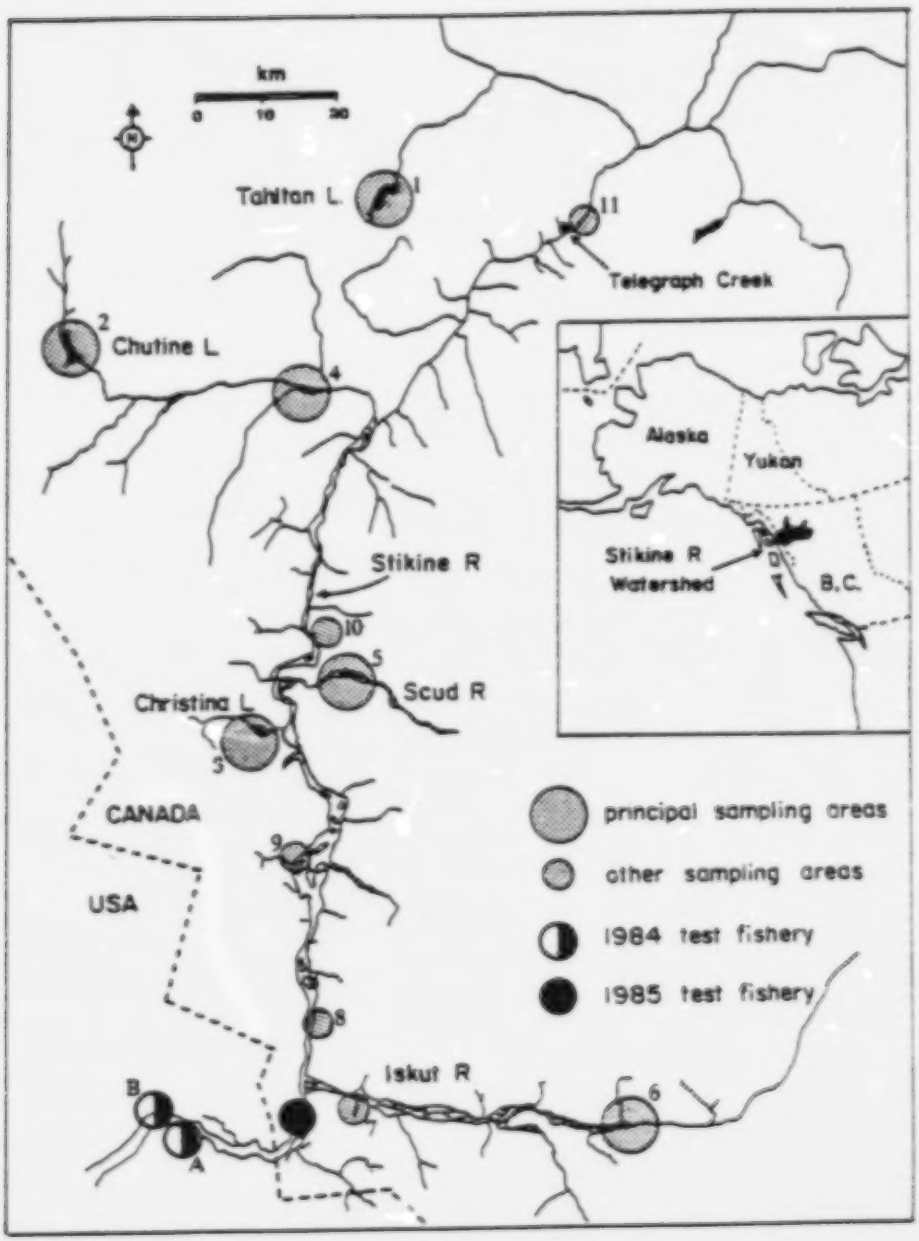

Fig. 1. The Stikine River watershed showing sampling areas and test fishing locations.

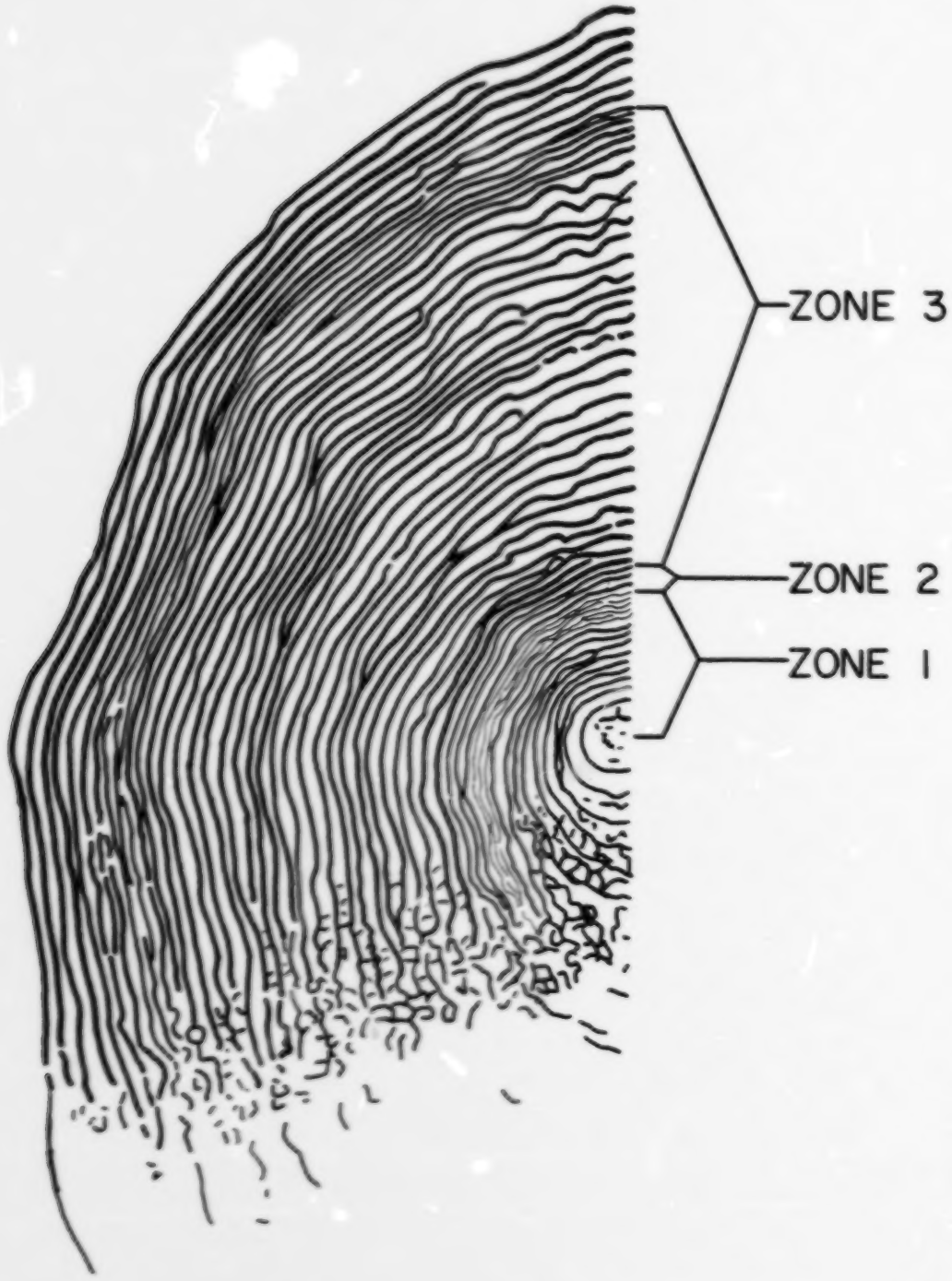

Fig. 2. Diagrams of typical sockeye salmon scales explaining growth zone definitions for age 1.2 (Fig. 2A) and age 2.2 (Fig. 2B) fish.

Fig. 2A.

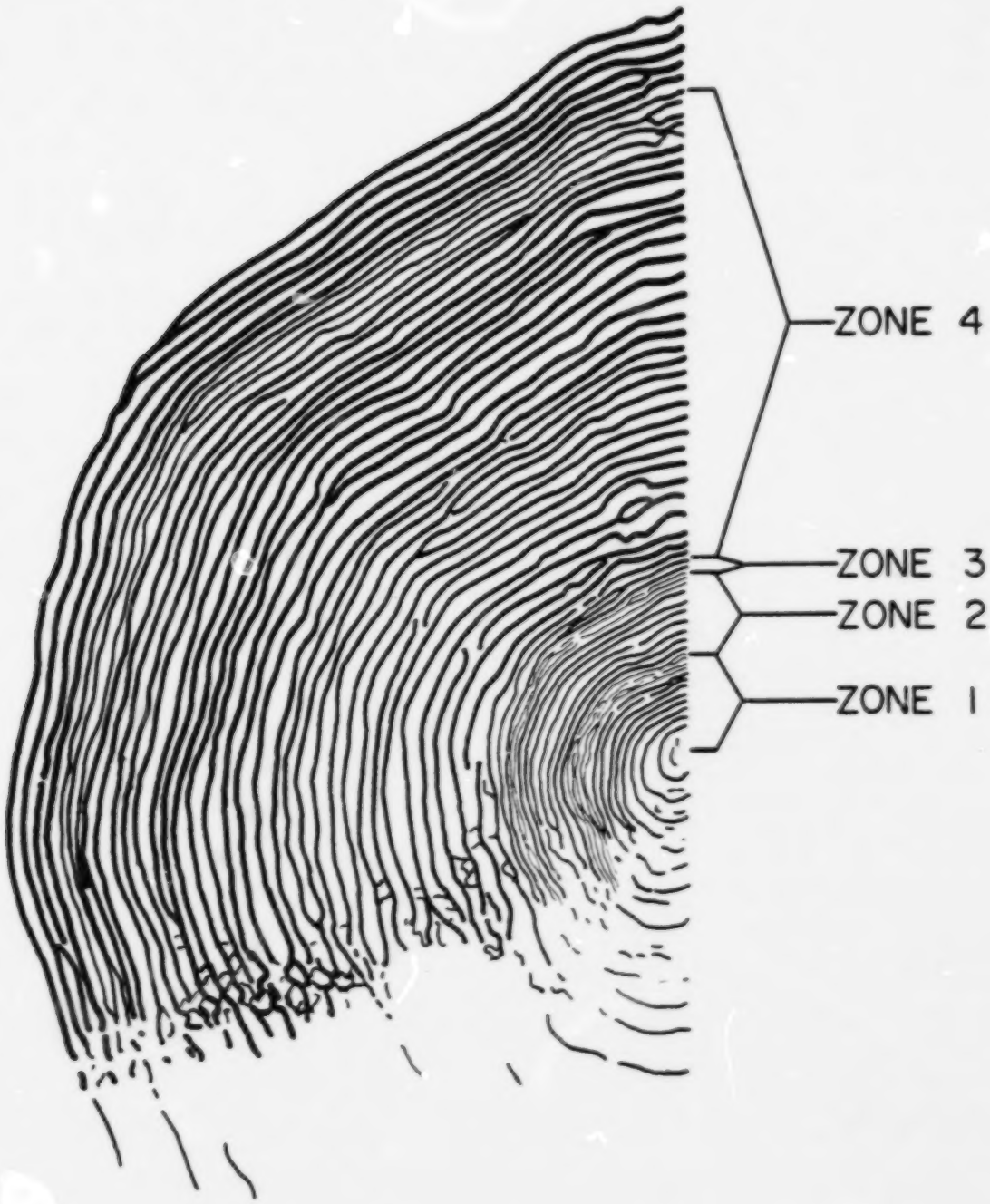

Fig. 2B.

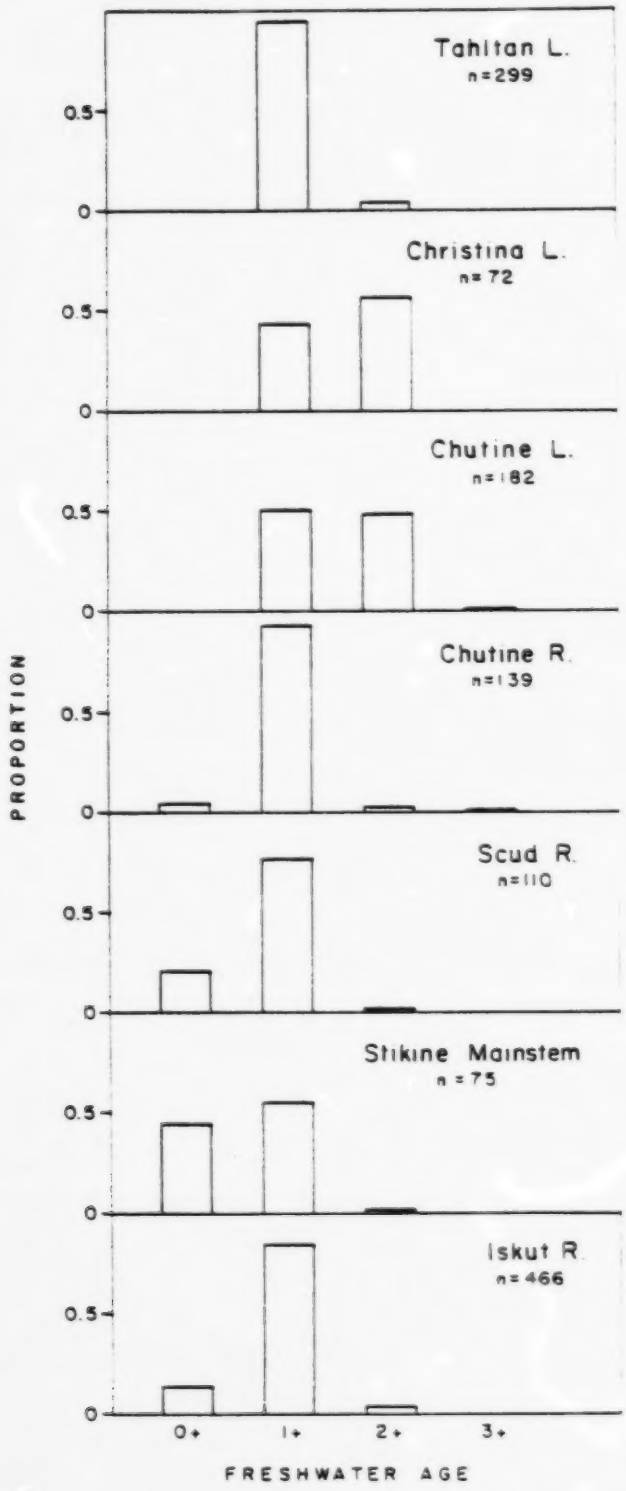

Fig. 3. Freshwater age composition of spawning sockeye collected in principal sampling areas, 1984-1985 (pooled).

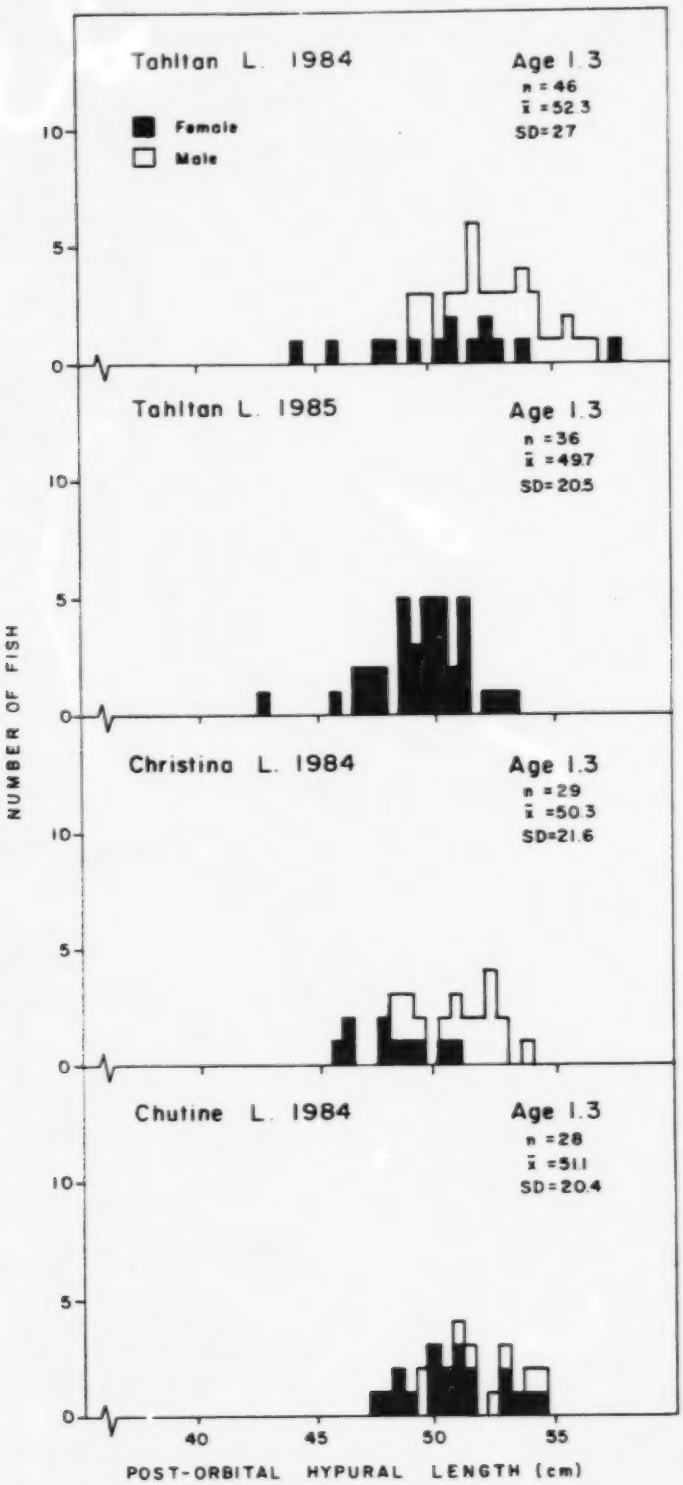

Fig. 4. Length distributions (post-orbital hypural) by age, sex, and year for spawning sockeye collected in principal sampling areas, 1984-1985. A. Age 1.3 sockeye from Tahltan Lake and glacial lakes.

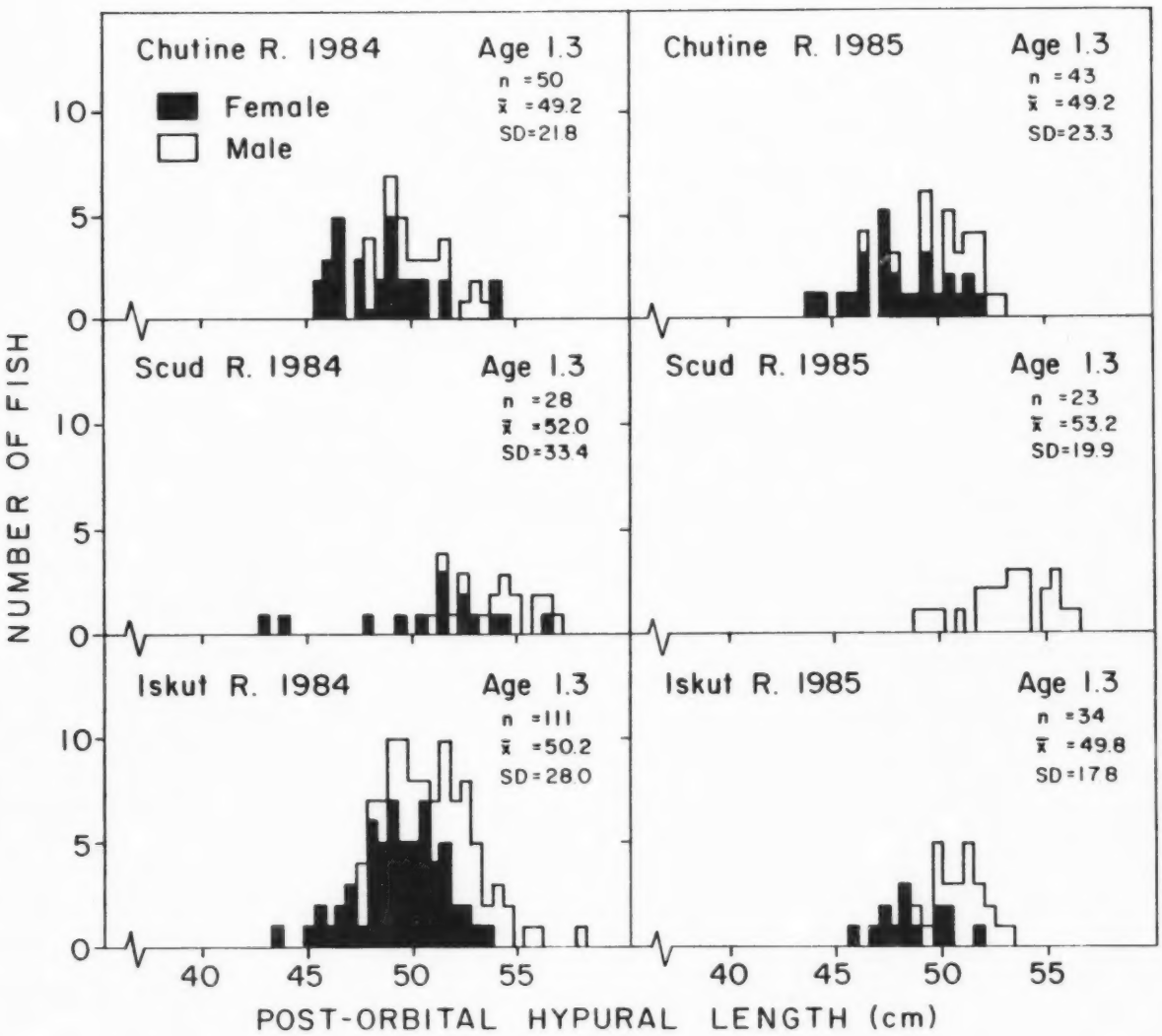

Fig. 4B. Age 1.3 sockeye from river stocks.

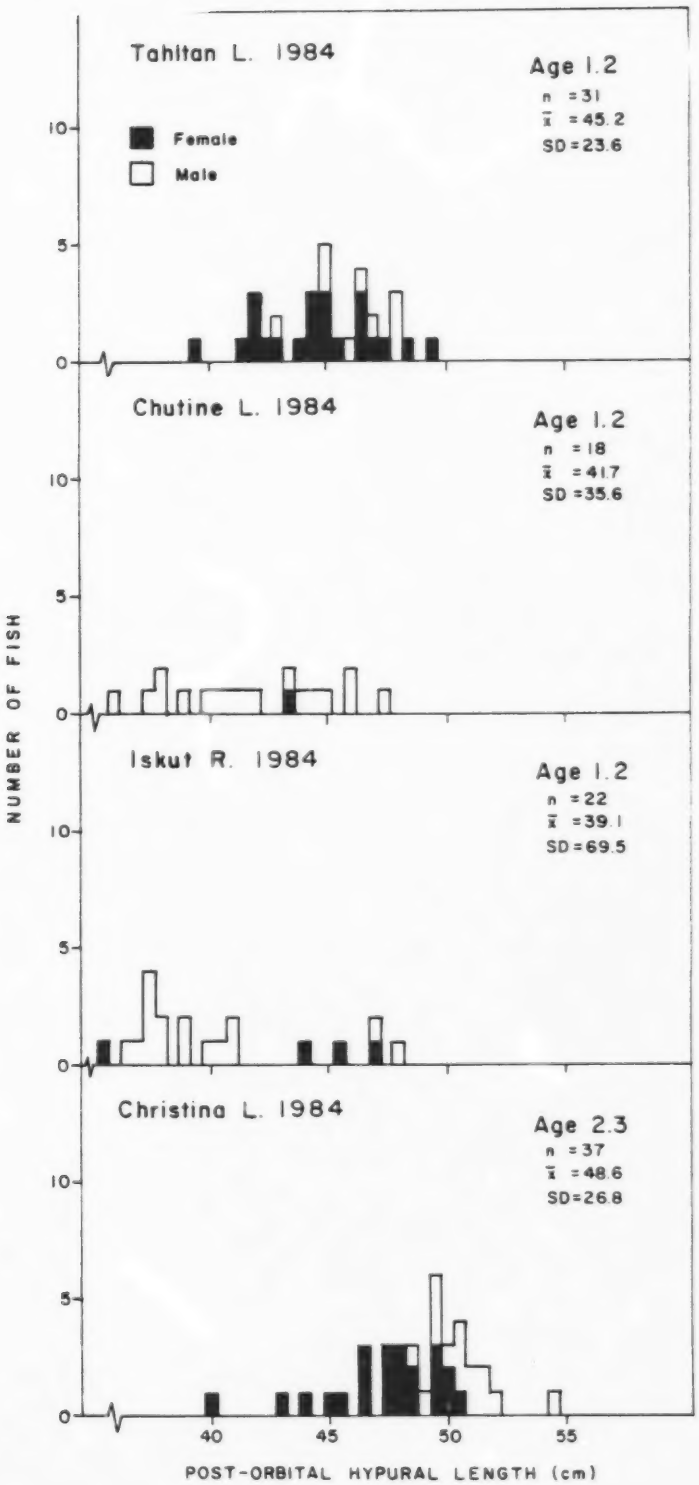

Fig. 4C. Other age classes.

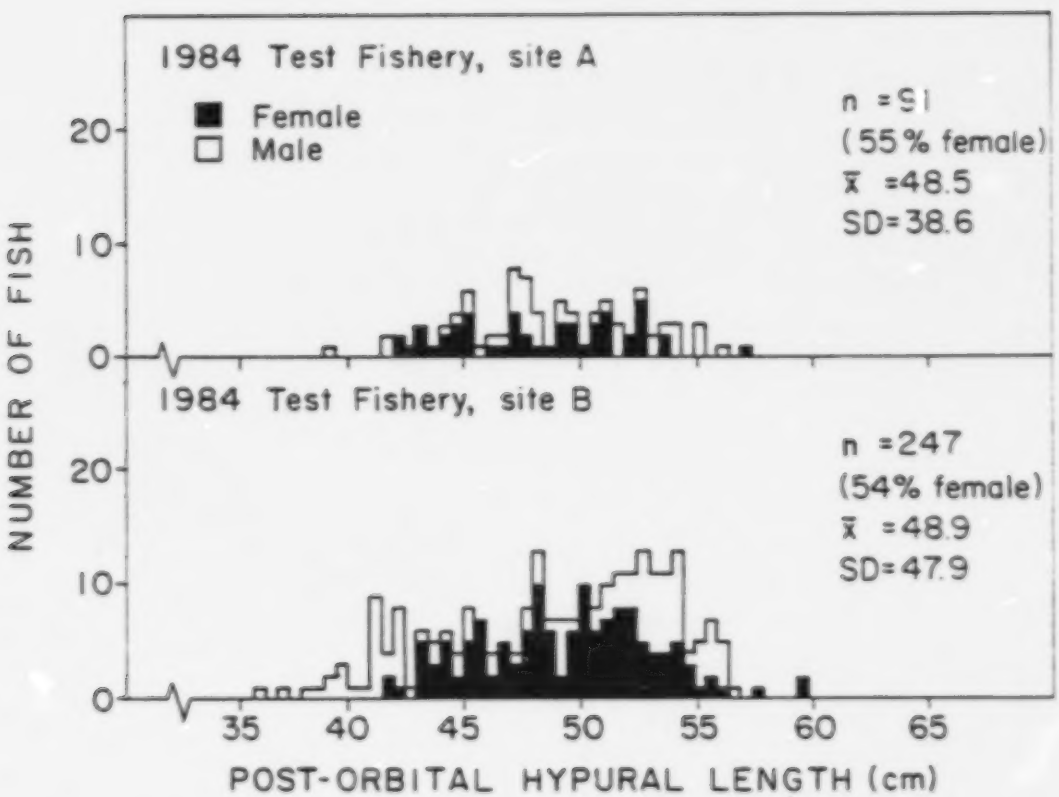

Fig. 5. Length distributions (post-orbital hypural) by sex of sockeye collected in test fisheries in the lower Stikine River in 1984 (Fig. 5A) and 1985 (Fig. 5B). All samples are weighted by catch per unit effort, and thus, should be representative of the overall sockeye run.

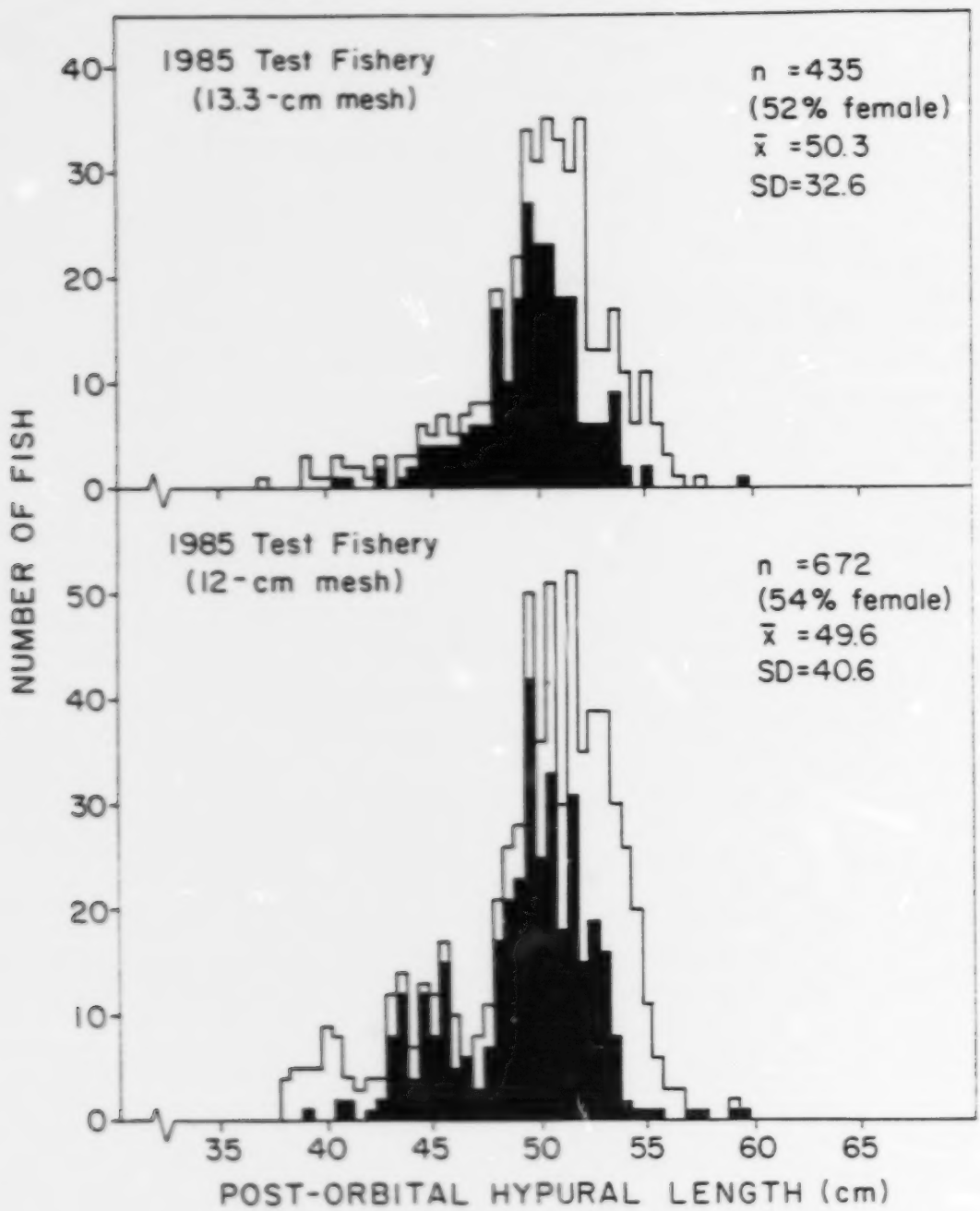
1985 Test Fishery
(13.3-cm mesh)
n =435
(52% female)
x̄ =50.3
SD=32.6
1985 Test Fishery
(12-cm mesh)
n =672
(54% female)
x̄ =49.6
SD=40.6
NUMBER OF FISH
POST-ORBITAL HYPURAL LENGTH (cm)

Fig. 5B.

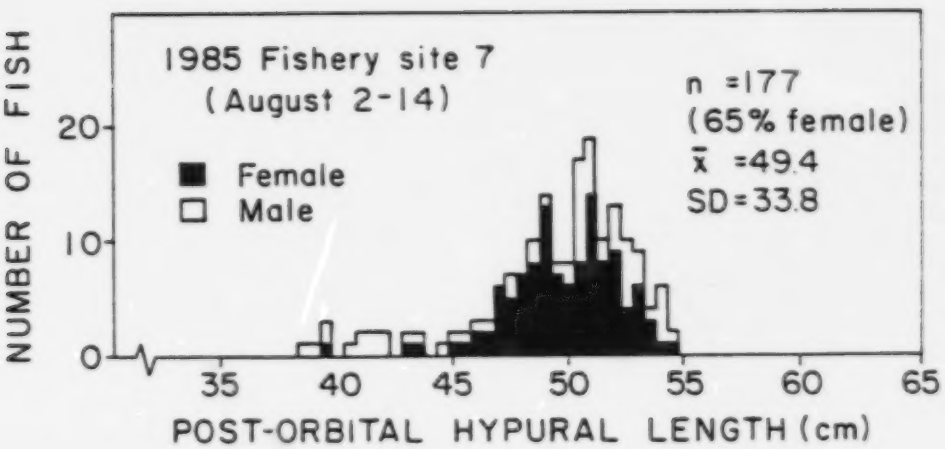

Fig. 6. Length distribution (post-orbital hypural) by sex for sockeye collected in a fishery at site 7 in the lower Iskut River, August 4-14, 1985.

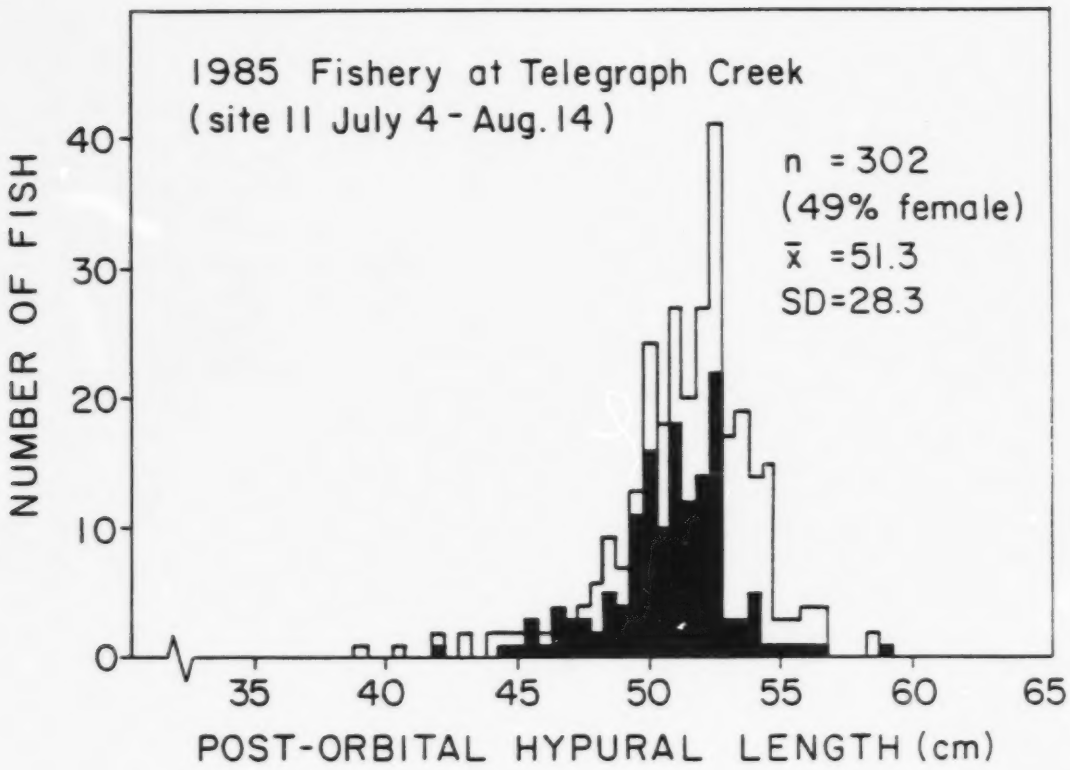

Fig. 7. Length distribution (post-orbital hypural) by sex for sockeye collected in the fishery at Telegraph Creek (site 11), July 4 - August 14, 1985.

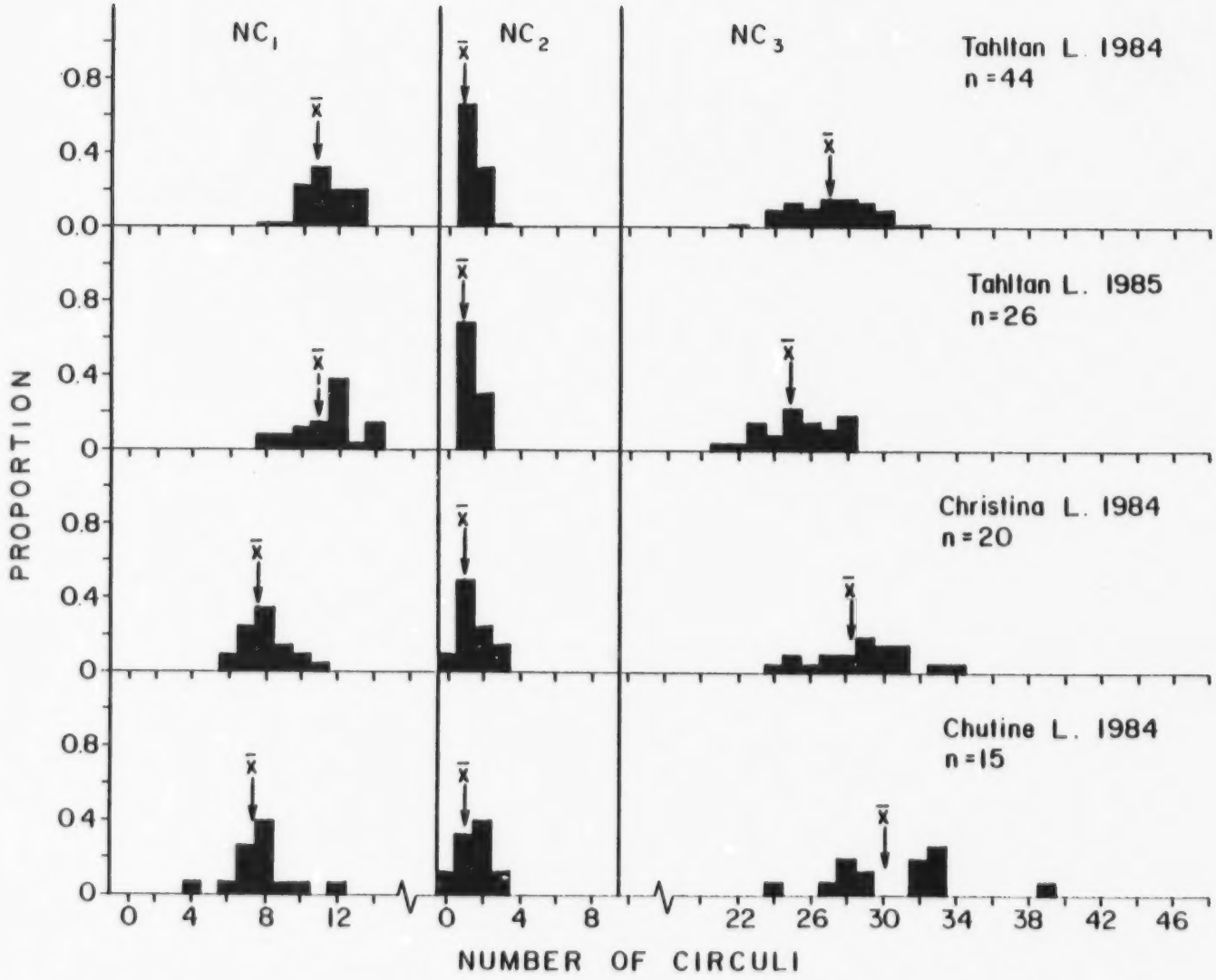

Fig. 8. Distributions of circulus counts in scale zones 1, 2, and 3 for age 1.3 sockeye collected from principal sampling areas, 1984-1985.
Fig. 8A.

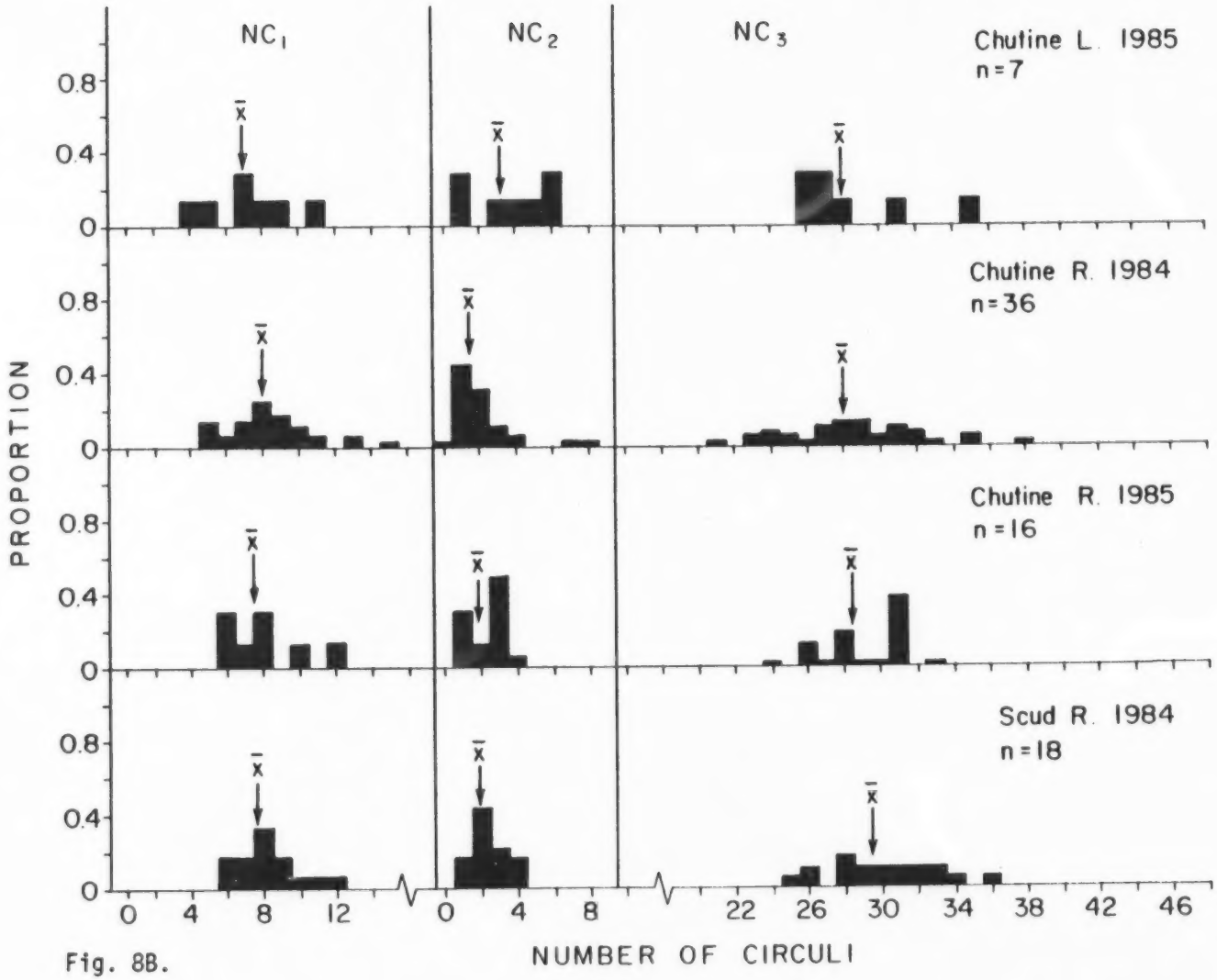
NC1
NC2
NC3
Chutine L. 1985
n=7
Chutine R. 1984
n=36
Chutine R. 1985
n=16
Scud R. 1984
n=18
PROPORTION
0.8
0.4
0
0 4 8 12
0 4 8
22 26 30 34 38 42 46
NUMBER OF CIRCULI

Fig. 8B.

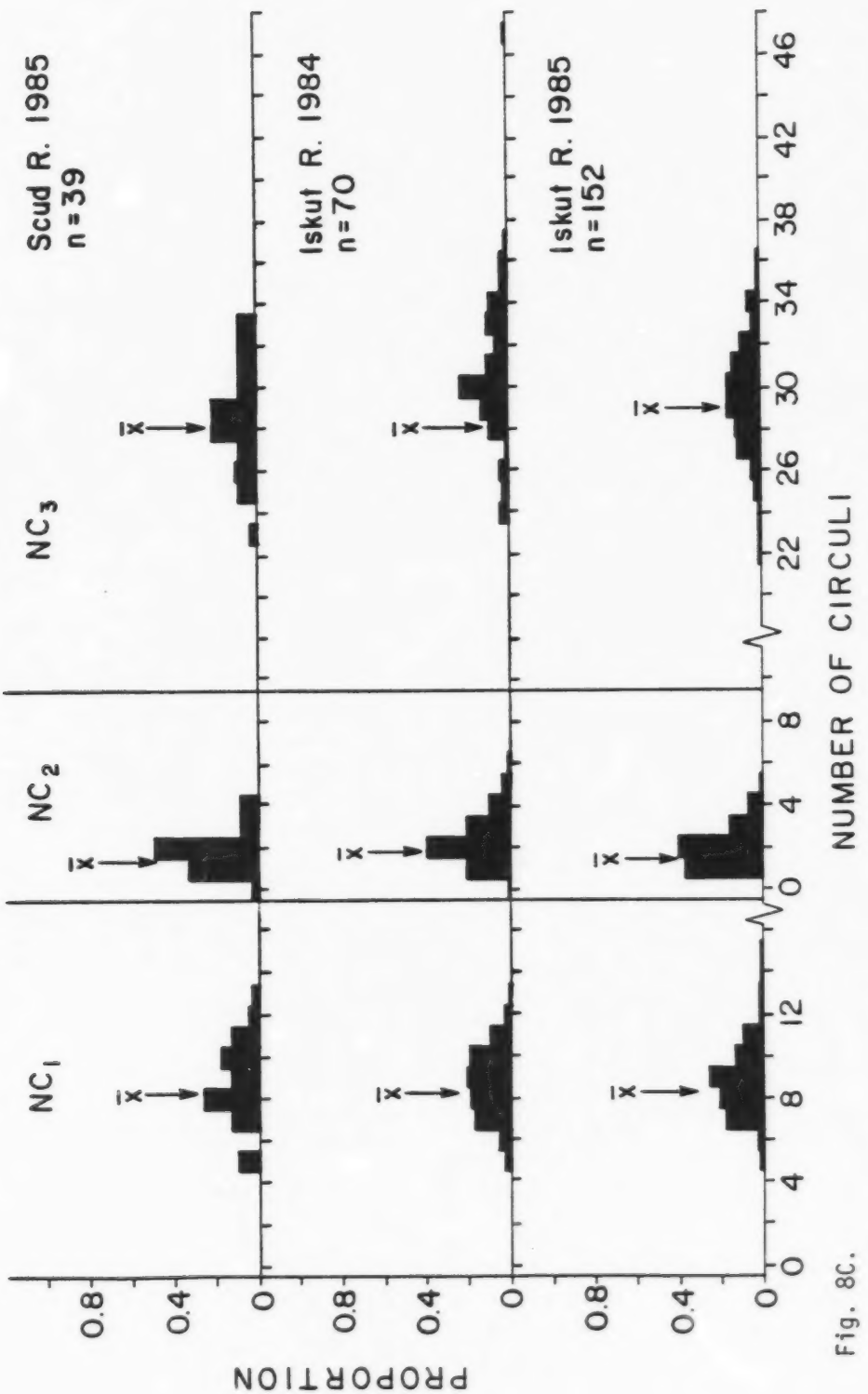
Scud R. 1985
n=39
Iskut R. 1984
n=70
Iskut R. 1985
n=152
NC1
NC2
NC3
PROPORTION
NUMBER OF CIRCULI
0.8
0.4
0
4
8
12
22
26
30
34
38
42
46

Fig. 8C.

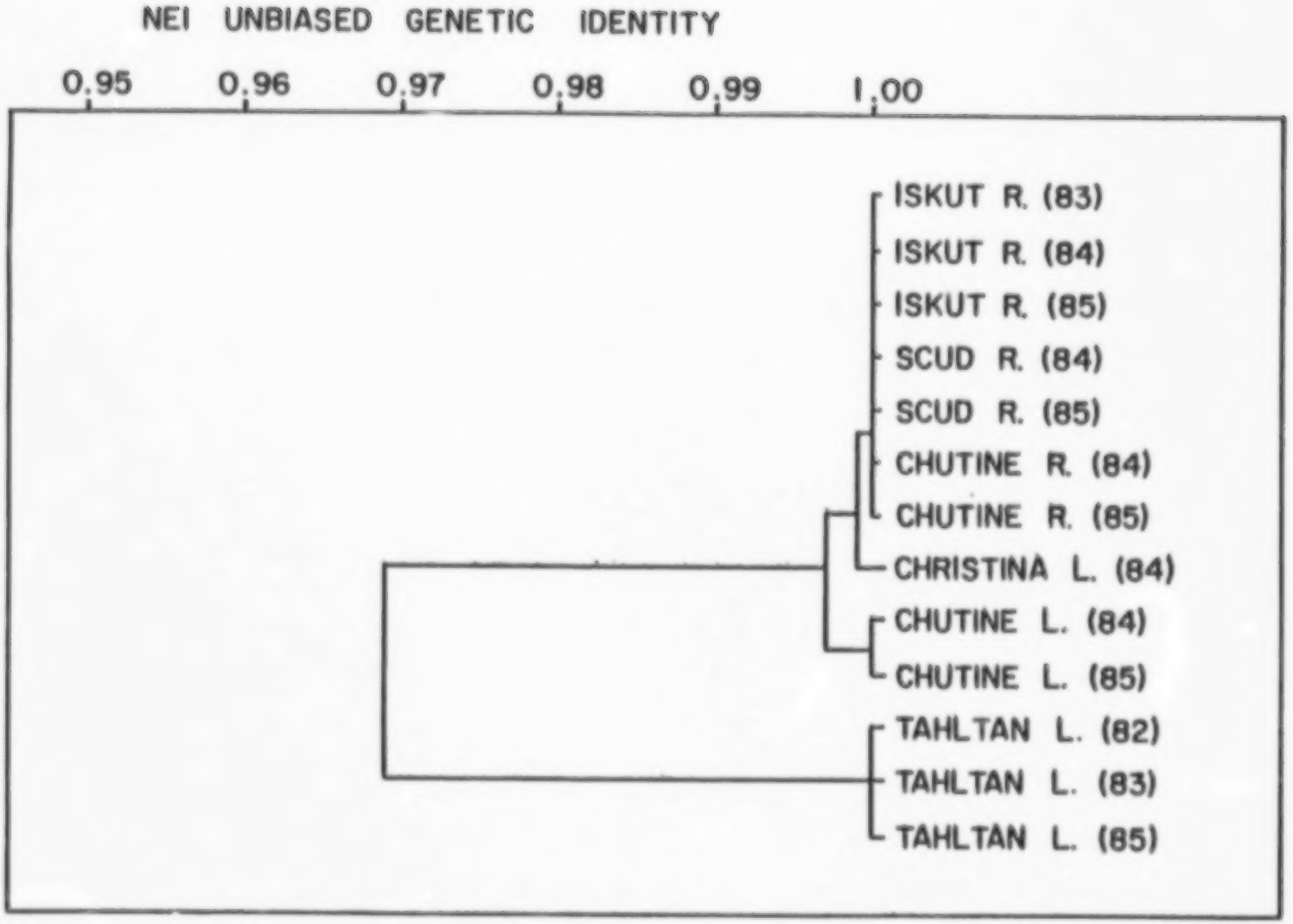

Fig. 9. Similarity dendogram based on Nei's (1978) unbiased genetic distance for sockeye salmon spawning in principal sampling areas.

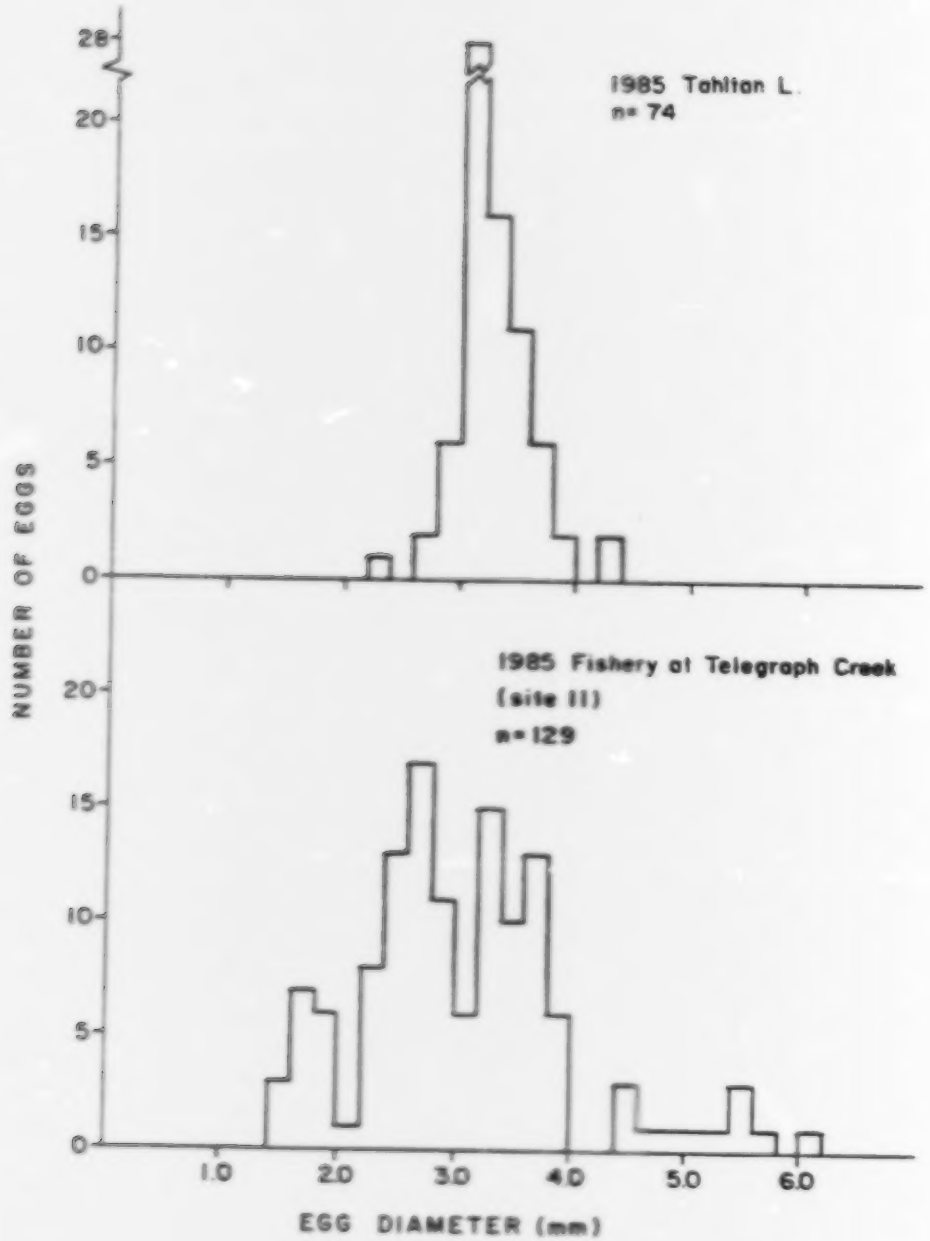

Fig. 10. Comparison of egg diameter distributions for female sockeye collected at the Tahltan Lake weir (July 29 - September 2, 1985) and in the Telegraph Creek fishery (July 4 - August 14, 1985).